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GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

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TABLE OF CONTENTS

*Tests of Impact on Pavements by the Bureau of Public Roads—VIII. By C. A. Hogentogler . . 1

Road Work in Pennsylvania 7

Some Unsolved Problems in Highway Economics By H. S. Fairbank 8

Wood Preservers Initiate Study of Creosoted Bridge Floors 10

EDITORIAL:

Nineteen Twenty-two 5

MEETINGS:

Calendar 10

American Society of Civil Engineers 10

Highway Engineers' Association at Missouri . . 10

PERSONAL MENTION 10

PUBLICATION 10

*Illustrated Article

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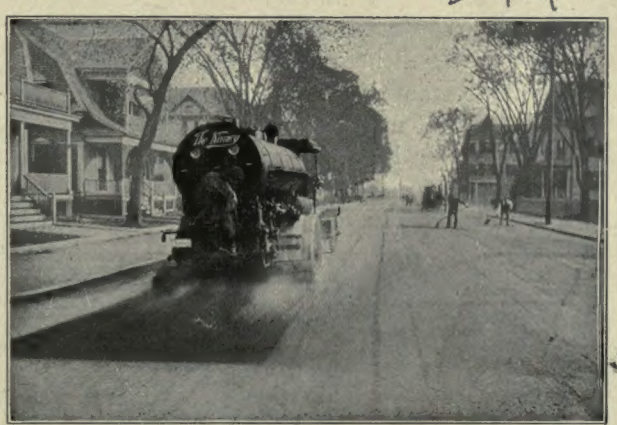

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GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

WITH WHICH IS INCORPORATED

THE HIGHWAY CONTRACTOR AND ROAD BUILDER

Vol. LXII NEW YORK, N. Y., JANUARY 4, 1922 No. 1

Tests of Impact on Pavements by the Bureau of Public Roads—VIII.*

By C. A. HOGENTOGLER†

(Concluded from December 28)

Resistances Determined Measure Beam Strength of Slabs

It must be borne in mind that the resistances determined in the tests do not measure the strength of the slabs when supported uniformly by their subgrades. Though the slabs themselves settled under the repeated blows, the relatively inelastic subgrades were pounded down still further. As the test proceeded, the space between the subgrade and slab became greater, permitting greater deflections of the slab until failure occurred. The resistances measured, therefore, indicate the strength of the sections acting as slabs with little or no support at their centers. They measure, in other words, what is commonly known as the "beam strength" of the slabs, and not their supported slab strength. Considering the conditions of the test the results are about what one would expect. A bituminous-filled brick slab would not be expected to show much beam strength, and a composite beam made up of parts which break separately and at different times could not be expected to show greater strength than the resistance of its strongest part. Very often the quality of "beam strength" is the factor which determines the serviceability of a road, but it must not be assumed that such is always the case.

Sections of Pavement Tested as Beams

As mentioned in the preceding article, it was thought that additional information might be obtained by constructing a series of beams representing the various slabs and determining their respective moduli of rupture when subjected to static loads centrally applied.

The beams, which were made in duplicate at the same time as the slabs, correspond to the slabs in design and workmanship. Their depths varied with the type of pavement represented, in breadth they ranged from 12 to 13 in., and all were exactly 7 ft. in length. At the time they were tested they had been aged in the open for about one year.

The diagram and photograph, Fig. 18, show the special device arranged to test the beams and illustrate clearly the methods of support and loading, and the apparatus for measuring deflections. The loads applied and the indicated moduli of rupture are given in Table 2.

The most useful purpose served by the beam tests is the confirmation of the conclusions drawn from the slab tests relative to the behavior of the monolithic slabs. As shown by Table 2, the average modulus of rupture for 1:1½:3 concrete alone is 546 lb. per square inch; for 1:3:6 concrete it is 475; for grouted brick, 712 lb. per square inch; and for monolithic beams only 385 lb., indicating that the full strengths of the concrete base and brick surface are not available when they are combined. The typical fractures, illustrated in Fig. 19, show how the tops of the monolithic beams shear from the bases under test, resulting in two independent beams. The resulting strength is shown by Table 2 to be somewhat greater than the sum of the strengths of the two parts. The only monolithic beams which showed a modulus of rupture approaching that of 1:3:6 concrete were those with a 2-in. base. The average for such beams was 465 lb. per square inch, while that of the concrete base alone was 475 lb. per square inch.

The low resistance shown by beams Nos. 47, 48, 49, and 50 (Table 2) are consistent with the behavior of the slabs under impact test, indicating that when there is a cushion, separating the top and the base, which allows one to break before the other, the strength is not proportional to the total thickness but rather to the thickness of the stronger part.

It will be noted that the average breaking loads for the 4, 6, 8, and 10-in., 1:1½:3 concrete beams are 910, 1,940, 3,500, and 5,600 lb. respectively, which follows the theory that the strength of a beam varies as the square of its depth. This relation is also shown by the breaking loads of 700 and 1,550 lb. for the 4 and 6-in., 1:3:6 concrete beams.

*From "Public Roads," the official publication of the Bureau of Public Roads, U. S. Department of Agriculture, November, 1921.

†Highway Engineer, Bureau of Public Roads, U. S. Department of Agriculture.

Table 3 gives the compressive strengths of specimens of concrete used in the slab construction. Nos. 1 to 7, inclusive, were 6x12-in. cylinders made from the 1:3:6 base concrete, and Nos. 8 to 12 were cylinders representing the 1:1½:3 concrete. Nos. 13 and 14 were cubes cut from slab No. 19 (1:3:6 concrete) after test, while Nos. 15 and 16 were cubes cut from slab No. 14 (1:½:3 concrete) after test. The average strength of the cylinders is 2,346 lb. for the 1:3:6 and 4,879 lb. for the 1:1½:3 mix, while for the cubes it is 3,436 lb. for the 1:3:6 and 6,222 lb. for the 1:1½:3 mix. From these averages the compressive resistance of 1:1½:3 concrete is indicated to be approximately double that of the 1:3:6 mix. This relation is different from that shown by the moduli of rupture of the two mixes. Compared in that respect the 1:1½:3 mix was but 15% better than the 1:3:6 mix.

Results of the Tests Summarized

In summarizing the results of the tests a word should be said concerning the part played by the subgrade in resisting the blows delivered to the slabs. At the beginning of the tests, it is assumed that the slabs were in intimate contact with their subgrades. Therefore the first blows delivered to the slabs must have been resisted almost entirely by the subgrades, since the slab resistance could be developed only by deflection, and no deflection was possible without corresponding deformation of the subgrade. Once deformed, however, the subgrades failed to return to their initial elevations, while the slabs did spring back after each blow. The result was that it was necessary for the slabs to deflect more and more under each succeeding blow before the subgrade could be brought into play to assist in resisting the blow. With increasing deflection the stress set up in the slabs increased, and the resistance to the blow was offered to an increasing degree by the slabs and to a diminishing degree by the subgrades. The slabs failed when the stresses set up exceeded their strengths; but at the instant of failure the blow was probably resisted partly by the subgrades. It appears therefore that the

TABLE 2.—RESISTANCES OF PAVEMENT SECTIONS TESTED AS BEAMS UNDER STATIC LOADS.

No. of beam	Description.				Total load at center.	Modulus of rupture
	Thickness of base.	Mix.	Thickness of surface.	Type of surface.		
	Inches.		*Inches.*		*Pounds.*	*Lbs. per sq. in.*
1	.....	1-1½-3 concrete	4	.....	430	302
2	.....	....do	4	.....	1,330	812
3	.....	....do	4	.....	980	620
4	.....	....do	6	.....	1,080	292
5	.....	....do	6	.....	2,880	773
6	.....	....do	8	.....	3,950	595
7	.....	....do	8	.....	3,250	498
8	.....	....do	8	.....	3,350	512
9	.....	....do	10	.....	6,110	583
10	.....	....do	10	.....	5,285	508
11	.....	....do	10	.....	5,410	520
12	.....	1-3-6 concrete	3	.....	520	525
13	.....	....do	4	.....	710	500
14	.....	....do	4	.....	710	511
15	.....	....do	4	.....	640	454
16	.....	....do	6	.....	1,520	450
17	.....	....do	6	.....	1,655	485
18	.....	.....	6	.....	1,330	399
19	.....	.....	6	.....	1,690	491
20	.....	.....	6	.....	1,560	459
21	2	1-3-6 concrete	3½	Vertical fiber brick, grout filler	1,340	433
22	2	....do	3½	....do	1,410	497
23	2	....do	3½	....do	1,410	485
24	2	....do	4	Repressed brick, grout filler	1,850	572
25	2	....do	4	....do	1,410	412
26	2	....do	4	....do	1,520	453
27	2	....do	4	Wire cut lug brick, grout filler	1,940	504
28	2	....do	4	....do	1,250	364
29	3	....do	3	....do	800	245
30	3	....do	3	....do	1,810	538
31	3	....do	3	....do	1,170	306
32	3	....do	4	....do	1,910	319
33	3	....do	3½	Vertical fiber brick, grout filler	3,590	362
34	4	....do	3½	....do	1,650	284
35	4	....do	3½	....do	2,040	344
36	4	....do	3½	....do	3,185	463
37	4	....do	4	Repressed brick, grout filler	1,910	319
38	4	....do	4	....do	1,460	254
39	4	....do	4	Wire cut lug brick, grout filler	2,420	421
40	4	....do	4	....do	2,110	304
41	4	....do	4	....do	2,480	403
42	5	....do	3	....do	2,040	340
43	5	....do	3	....do	2,740	444
44	6	....do	4	Repressed brick, grout filler	3,510	400
45	6	....do	4	....do	3,060	353
46	6	....do	4	....do	4,210	427
47	6	....do	4	Wire cut lug brick, tar-mastic filler	1,340	132
48	6	....do	4	....do	1,910	184
49	6	....do	4	Wire cut lug brick, tar-mastic filler, screening cushion	1,655	154
50	6	....do	4	Wire cut lug brick, tar filler, screening cushion	825	95
51	6	....do	4	Wire cut lug brick, grout filler	2,810	269
52	6	....do	4	....do	2,610	305
53	6	....do	4	....do	2,480	306
54	6	....do	4	....do	1,850	351
55	7	....do	3	....do	4,840	485
56	7	....do	3	....do	2,925	358
57	.....	.....	3½	Vertical fiber brick, grout filler	700	574
58	.....	.....	3½	....do	950	991
59	.....	.....	4	Repressed brick, grout filler	1,080	715
60	.....	.....	4	....do	955	640
61	.....	.....	4	Wire cut lug brick, grout filler	955	623
62	.....	.....	4	....do	1,020	679
63	.....	.....	4	....do	1,280	829
64	.....	.....	4	....do	900	608
65	.....	.....	4	....do	1,120	754

slab resistances indicated by the tests were greater than they would have been if the centers of the slabs had been entirely without subgrade support. How closely the conditions of the tests in this respect conform to the conditions which exist in actual pavements it is impossible

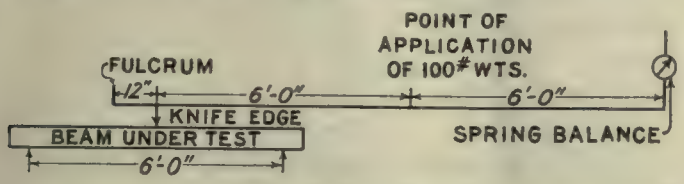

FIG. 18.—APPARATUS FOR TESTING BEAMS

to determine, but it is believed that similar conditions do exist under many pavements.

For the test conditions of size, loading, and support of slabs, as previously described, the following indications are noted:

The resistances shown by 1:1½:3 concrete slabs, 7 ft. square, are very consistent, increasing uniformly with increase in thickness. In slabs 6 in. and more in thickness only primary cracks developed, while 4-in. slabs shattered and punched out at the center. From this it would seem that plain concrete surfaces of 4-in. thickness are inadequate for heavy motor-truck traffic.

Comparison of the results of the concrete beam tests under static loads and the tests of concrete slabs under impact blows shows that the relation of resistance to thickness is not the same under the two conditions of loading. Beginning with the 4-in. slab which resisted 14,000 lb. equivalent static load, the resistance of the slabs, as measured by the equivalent static load at failure, increased 5,000 lb. with each inch of additional thickness, while the beam resistances varied as the squares of their depths. It must be remembered that the beam tests showed the resistance of the specimens alone, while the slab results were conditioned by the bearing power of the subgrade. This might account in part for the difference observed; but according to theory the resistance of beams to impact does vary directly with the thickness. It would seem that the subgrade influence affected the resistance shown by the thinner slabs much more than that of the thicker.

The monolithic slabs in most cases showed less resistance than the 1:1½:3 concrete slabs of the same depth. Failure of the former seemed to result from the shearing of the brick top from the concrete base before full resistance of the monolith was developed. This allowed the specimens to develop at most only the sum of the resistances of the two parts. The monolithic sections tested as beams under static loads failed in the same way, but the resistance of the beams seemed to be slightly in excess of the sum of the top and bottom strengths, while the slab resistances compared favorably with the sum of the resistances of the two parts. This would indicate that higher shearing stresses are developed by impact than by equivalent static loads.

With possibly one exception (slab No. 106) the grouted-brick tops with sand-cement cushions on concrete bases showed less resistance than the monolithic sections.

Grout-filled brick tops with sand and screening cushions on concrete bases showed slightly greater resistances than would be expected from the bases alone.

Grouted-brick surfaces compared favorably with 1:1½:3 slabs of equal thickness, while grouted-brick beams showed resistances in excess of those offered by equal thicknesses of 1:1½:3 concrete.

As would be expected the beam strengths of the bases were not much increased by bitumen-filled brick tops.

With few exceptions other than the monolithic slabs, the indications were that failure occurred because of increase of the force of impact rather than by repetition of impacts of the same magnitude.

It was generally indicated that the resistance of the specimens increased with an increase in the bearing power of the subgrade as shown by the subgrade determinator.

There seemed to be no direct relation between the moisture content and the supporting value of the subgrade. It was found that the supporting value was least in the early spring after frost had left the ground and that it increased through the summer months. This increase of supporting value occurred notwithstanding attempts made to keep the subgrade under about one-half the slabs in a moist condition. During the summer it was noted that the supporting value was not much impaired by rains. Observations made at different periods, however, did show a higher moisture content in the subgrades surrounded by the ditches which were kept full of water than in the subgrades surrounded by dry

TABLE 3.—COMPRESSIVE STRENGTH OF CONCRETE SPECIMENS.

Specimen No.	Mix.	Ultimate total strength.	Unit strength.
		Pounds.	*Lbs per sq. in.*
1	1-3 -6	62,220	2,200
2	1-3 -6	68,530	2,420
3[1]	1-3 -6	72,000	2,540
4[2]	1-3 -6	64,540	2,280
5	1-3 -6	82,700	2,920
6	1-3 -6	56,200	1,990
7	1-3 -6	58,570	2,070
8	1-1½-3	128,000	4,540
9	1-1½-3	151,000	5,340
10	1-1½-3	149,000	5,270
11	1-1½-3	124,500	4,400
12	1-1½-3	137,000	4,850
13[3]	1-3 -6	86,050	3,442
14[3]	1-3 -6	81,520	3,430
15[3]	1-1½-3	145,100	6,030
16[3]	1-1½-3	156,290	6,415

1 Dry Mix. 2 Wet Mix. 3 Cubes cut from slab specimens.

ditches. In general, also the supporting value was less in the former.

The relation between the strength of 1:1½:3 and 1:3:6 concrete specimens, as shown by both the beam and slab tests was different from that shown by the compressive tests on cylinders and cubes. From the latter the re-

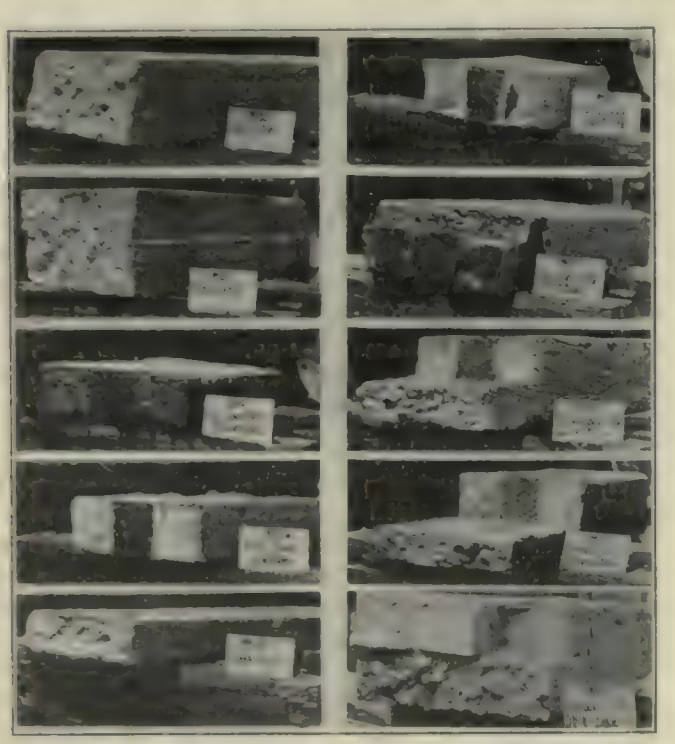

FIG. 19.—VIEWS OF TYPICAL BEAM FRACTURES

sistance to compression for 1:3:6 was shown to be about 50% of that for the 1:1½:3 mix, while the difference between the two mixes as indicated by beams and slabs does not exceed 15 to 20%. It will be remembered also that the wear tests on pavement sections[1] failed to disclose any relation between compressive resistance and resistance to wear of the concretes made of the several different aggregates.

As a result of the studies with copper cylinders and the derivations from the space-time curves and also as a result of the slab and beam tests, it appears that usable relations have been established between static loads and impacts such as were delivered in these tests.

Practical Application of the Test Results

In all the impact experiments which have been conducted by the Bureau of Public Roads the end which has been constantly kept in view is the development of a rational method for the design of roads to withstand this destructive force. No investigation has been undertaken unless there was reason to believe it would contribute something of value toward this end. It has been necessary to do a great deal of work the results of which have had no immediate practical value. When it is considered, however, that at the outset of the tests there was not even an instrument with which to measure the effects of impact, it does not seem surprising that the earlier work could not be turned to instant practical use. The first stage of the tests, devoted to the search for a measuring instrument, resulted in the adoption of the copper-cylinder method. The second consisted in the use of the cylinders to measure the magnitude of the impact forces delivered by motor trucks moving at various speeds, with different conditions of tire, spring, load, and contact with the road. The third stage, which has been described in this series of articles, dealt with the development of an improved measuring instrument and the determination of the effect of impact on various pavements. Information of the character furnished by these series of tests is all that is needed for the solution of the problem of design, so far as the force of the impact is concerned.

The range of conditions dealt with is not yet extensive enough and the data are not numerous enough to satisfy the requirements of practical design; but, in the main, what remains to be done is simply to fill in the details of the outline already laid down.

The manner in which the test results can be utilized is illustrated by the following example in which the conditions assumed correspond to the conditions of the tests.

Let us suppose a concrete pavement is to be designed to sustain safely the impact of a 5-ton truck loaded to capacity. It will be assumed that the character of the road surface and the condition of the tires of the vehicles which will use the road are such that the impact

TABLE 4. IMPACT CAUSED BY DIFFERENT MOTOR TRUCKS.

Rated capacity of truck	Load.	Load on one rear wheel.			Equivalent static load for different heights of fall		
		Total	Spring.	Unsprung.	0	¼ inch	1 inch
Tons.	*Tons.*						
1½	1¾	3,475	2,410	1,065	5,500	7,500	10,200
1½	1¾	3,475	2,410	1,065	4,500	6,300	11,500
1½	2¼	4,240	3,175	1,065	4,700	10,000	16,000
1½	2¼	4,240	3,175	1,065	4,900	5,800	9,200
2	2	4,300	3,300	1,000	6,800	7,800	11,500
2	2	4,300	3,300	1,000	6,800	8,500	13,400
2	2	4,300	3,300	1,000	6,800	7,900	11,000
2	2	4,300	3,300	1,000	6,800	7,500	11,000
2	3	4,900	3,900	1,000	7,200	8,500	14,000
2	3	4,900	3,900	1,000	7,300	8,600	13,700
2	3	4,900	3,900	1,000	6,800	8,000	11,000
3-3½	2½	5,150	3,450	1,700	8,400	9,200	15,700
3-3½	2½	5,150	3,450	1,700	8,200	8,700	11,800
3-3½	2½	5,150	3,450	1,700	8,200	9,300	14,100
3-3½	2½	5,150	3,450	1,700	6,900	9,200	21,500
3-3½	2½	5,150	3,450	1,700	8,000	8,200	12,200
3-3½	2½	5,150	3,450	1,700	8,700	8,200	13,000
3-3½	4½	7,000	5,300	1,700	...	10,000	19,000
3-3½	4½	7,000	5,300	1,700	9,700	9,700	19,000
3-3½	4½	7,000	5,300	1,700	9,300	9,800	17,700
3-3½	4½	7,000	5,300	1,700	9,200	11,000	17,200
3-3½	4½	7,000	5,300	1,700	10,000	10,000	18,000
3-3½	4½	7,000	5,300	1,700	10,000	11,000	15,800
5	5	7,900	5,950	1,950	11,000	12,800	18,000
5	5	7,900	5,950	1,950	11,000	12,500	19,000
5	5	7,900	5,950	1,950	9,000	10,000	16,000
5	5	7,900	5,950	1,950	9,200	10,700	15,500
5	5	7,900	5,950	1,950	9,200	9,700	13,000
5	5	7,900	5,950	1,950	9,500	...	15,000
5	7½	10,600	8,650	1,950	12,200	13,300	20,000
5	7½	10,600	8,650	1,950	12,000	13,700	21,000
5	7½	10,600	8,650	1,950	11,500	12,500	18,500
5	7½	10,600	8,650	1,950	11,500	12,600	17,200
5	7½	10,600	8,650	1,950	11,000	11,200	16,800
5	7½	10,600	8,650	1,950	11,200	12,100	15,800

of the vehicles will be equivalent to that which would result by dropping the rear wheels from a height of one-fourth inch. Let it be assumed also that the pavement is to be designed to span small areas in which it will receive very little subgrade support, a condition similar to that which existed in the tests.

(Continued on page 6)

[1] Accelerated Wear Tests by the Bureau of Public Roads. Public Roads, June, 1921.

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

Founded January, 1892

E. L. POWERS
Editor

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Copy for advertisements must reach the New York office by noon on Tuesday of the week before date of issue if proofs are to be submitted.

Copy for classified and other advertisements where proofs are not required will be accepted until noon on Monday of the week of issue.

Articles by road builders are solicited. They should be short and, if possible, accompanied by photographs. Those accepted will be paid for at current rates.

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Volume LXII January 4, 1922 Number 1

NINETEEN TWENTY-TWO

The road builder, it seems to us, has every reason to look forward with abundant optimism to the coming season. Notwithstanding the great volume of work that has been done in the road building field during the past twenty years, the great work of providing the country with an adequate highway system hardly has been commenced. One of the greatest material undertakings of man lies ahead of the road builders of America and there is every reason to look to the coming season to mark the beginning of an era of unprecedented achievement.

The two great forward steps that have been taken in road betterment were the adoption of the state aid principle and the inauguration of federal aid. When a few of the eastern states established the former as the basis of highway work some twenty years ago, road improvement in this country really began. As state after state took up the plan, road work evolved from a local affair to a matter of state-wide effort and the patchwork of town and county highways began to take on the semblance of state systems of connected highways. In 1916, when the first federal aid law was enacted, the possibility of welding these state systems into a national system that would serve the country at large, as well as the states, the counties and the towns, became something more than the dream of a few men with the vision of what highway transportation would sometime mean to the nation.

While these changes in policy were being worked out, the automobile and the motor truck had so far replaced the horse-drawn vehicle of the early days of real road building, and had so added to the volume of traffic upon the roads, that highway work had assumed new importance and the science and art of building and maintaining roads had become a highly specialized and generally recognized branch of engineering. New methods had been devised and materials previously little used had found wide employment in both street and road work. The road builder had found a broader field of service, for he had come to a realization that the problems of economics, of legislation, of finance and of transportation were as much his as were the mere technical phases of his work.

Under normal conditions, 1917 might have marked the beginning of real progress in the building of the nation's roads. But the war and its aftermath intervened. Restrictions upon the programs that had been formulated, scarcity of labor and materials, high prices, curtailed railway facilities, prohibitive freight rates, financial stringency, and a host of lesser hindrances, have held back road construction and maintenance during the past few years.

Now the war is over and there is reason to believe that the worst of its reaction has passed, that the pendulum has begun its swing back to normal conditions. Congress has enacted a new federal aid law from which much is expected, and has made new appropriations. Prices and freight rates have begun to show signs of reaching stable levels, labor is plentiful, more efficient and less costly, bonds are finding better markets, and the states and their subdivisions are ready to go ahead with expanded pragrams. In the technic of highway engineering great progress has been made and important researches and experimentation are in progress. Better and better administrative methods are being adopted and the economics of road improvement are receiving more nearly the attention they deserve and require. The highway engineer occupies a far more responsible position than he did even five years ago and he has gained much in the esteem of his fellow engineers in other lines and in appreciation by the public that employs him.

All things considered, the outlook for the 1922 road building season is reassuring. Unless something unforeseen occurs—and there is no reason to expect anything of the kind—the coming year should bring to road builders opportunities for service and for their own advantage that they have never had before.

(Continued from page 4)

To meet these requirements the designer would refer first to the results of the measurement of motor truck impact. A brief summary of these results is given in Table 4. The table shows the impacts delivered by the rear wheels of trucks of various sizes, variously loaded, and dropped upon the road surface from three different heights. The average impact resulting from a one-fourth inch drop of the rear wheels of a 5-ton truck loaded with 5 tons, as shown, is equivalent to a static load of about 11,000 lb.

Several corrections must be applied to this value before it can be used. In the first place the tabular values represent the impacts delivered by trucks equipped with new solid tires. The tests showed that the use of worn tires might increase the impact by from 15 to 60%. Assuming that the use of badly worn tires will be prohibited by law let us apply a correction of 30% which will increase the tabular average to 14,300 lb. equivalent static load.

Also since the tabular values were obtained by the use of ½x½-in. copper cylinders, they are less than the true impacts, and it will therefore be necessary to apply the correction indicated in the first article of this series. Finally, as insurance against overloaded trucks, and other conditions such as the use of nonskid chains which

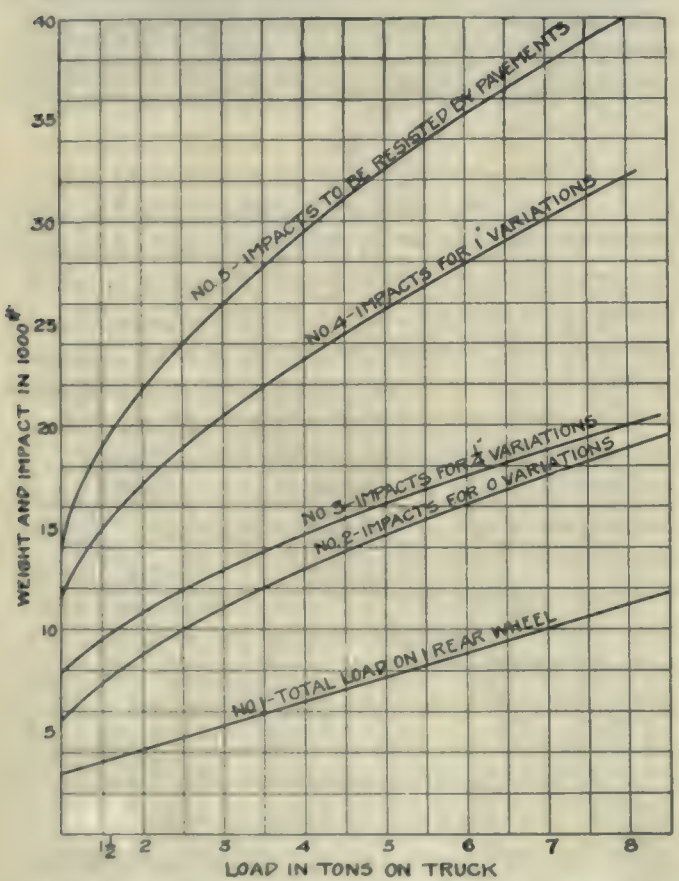

FIG. 20.—TOTAL WHEEL LOADS AND IMPACTS FOR TOTAL LOAD CARRIED ON TRUCK

would increase the impact, let us double the estimated impact. The tabular values of impact increased by 30% for tire condition and corrected to eliminate the effect of the copper cushion are shown in curves 2, 3, and 4 of Fig. 20. Curve 1 shows the total static load on one rear wheel and curve 5 shows double the values of the corrected impacts for the ¼-in. drop. In each case the impacts or loads are shown in relation to the load carried by the truck. Referring then to curve 5, we find that in designing a pavement for a 5-ton truck loaded to capacity, provision must be made for an eqpivalent static load of 32,500 lb., which is slightly more than four times as great as the total load on one rear wheel of the truck as shown by curve 1.

Having thus determined the impact for which the surface is to be designed, the thickness required is indicated

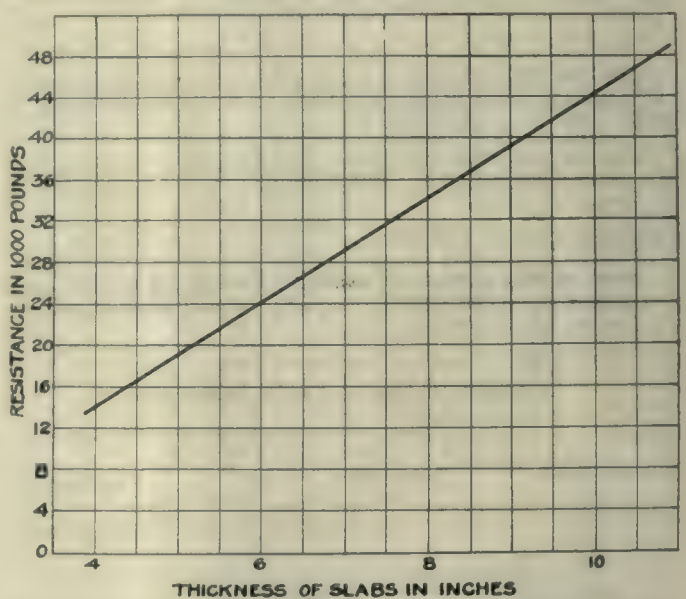

FIG. 21.—RESISTANCE OF DIFFERENT THICKNESSES OF 1 :1½ :3 CONCRETE SLABS

by the results of the slab tests reported in this article. For 1 :1½ :3 concrete slabs the average results of these tests are shown in Fig. 21, which gives the resistance of slabs of various thicknesses. Referring to this figure it is found that a 1 :1½ :3 concrete pavement to withstand the impact of 5-ton trucks loaded to capacity and operated under the assumed conditions must have a thickness of between 7½ and 8 in.

Proceeding in a similar manner from other assumptions it can be shown that the thicknesses of 1 :1½ :3 concrete required for various sizes of trucks are as follows: for a 1½-ton load, 5 in.; for a 2-ton load, 5.5 in.; for a 3-ton load, 6.4 in.; for 4 tons, 7.1 in.; for 5 tons, 7.7 in. and for a 7½ton load, 8.9 in.

These thicknesses are given merely as the results of an example which is cited to illustrate a method of design. They are not to be considered as the proper thicknesses of actual pavements to accommodate vehicles of the several capacities; nor is the curve in figure 21 *to be understood to represent anything other than the average relation of resistance to thickness in the particular tests which have been described.*

One of the reasons why the results can not be generally applied is that they relate only to the special subgrade conditions which existed at the Arlington Experi-

mental Farm. There is no assurance that the resistances of the slabs tested would not have been widely different if they had been laid on different subgrades. On the contrary, there is every reason to believe that they would have been different.

Another obvious reason is that the slab resistances used were derived from tests in which the impact was delivered only to the centers of the 7-ft. slabs, and it is known that this is the most favorable condition. Less resistance would have been offered to impact applied at their edges, and still less to blows delivered at their corners.

These reasons indicate the need for further research. In respect to the subgrade the first need is to devise a method by which the supporting value may be measured, the next is to find out how and to what extent it is affected by moisture and other natural conditions. These problems solved, it will still be necessary to study the changes which affect the shape of the subgrade, such changes, for example, as are caused by frost and the pounding of traffic, for with rigid surfaces the support offered by the subgrade depends not only on its supporting value but also upon the nature of its contact with the surface. And this study will necessarily include the behavior of the surfaces as well as the subgrade, for the desired contact may be lost by the movement of the road slab itself. The bureau's tests have shown already that such movement occurs daily as a result of temperature changes.[2]

The determination of the edge and corner resistance of the slab presents no great difficulty. It is confidently expected that reliable data on this subject will be developed by tests now under way; and with the knowledge gained it should not be a difficult matter to design all parts of the slab to have equal strength.

What doubt remains as to the intensity of the impact which may be delivered by vehicles operating on actual roads should be cleared up by means of the impact recorder designed by the bureau and awaiting only minor adjustments preparatory to experimental use. This apparatus, attached to a motor truck, will give autographic space-time curves similar to those drawn by the instrument attached to the stationary impact machine, and thereby permit the measurement of impact on actual highway surfaces.

Oher tests which are already in progress will yield further data on the resistance offered by bituminous-topped and reinforced-concrete pavements. If the subgrade problem can be solved satisfactorily the information which will ultimately become available should give a very clear conception of the type and thickness of pavement necessary for any given kind of traffic.

[2]"Subgrade Drainage Tests Yield Interesting Preliminary Data." Article by Ira B. Mullis. Public Roads, October, 1921.

ROAD WORK IN PENNSYLVANIA

State Highway Department Builds 2,777 mi. of Highway During Past 17 Years—During the Year 1921 State Constructed 670 mi. of Durable Roads.

During the last seventeen years the State Highway Department of Pennsylvania has put under contract 2,776.95 mi. of roadway.

During the years 1919, 1920 and 1921, under the administration of State Highway Commissioner Lewis S. Sadler, the department completed 1,340 mi. of durable highway, and in addition entirely resurfaced 1,207 mi. of macadam.

The resurfacing operations of the department began in 1914, in which year the practice of awarding contracts for macadam roadway construction was practically discontinued. In the years beginning with 1914 and ending with 1921 the State Highway Department resurfaced 2,409 mi. of macadam roadway.

It was in 1919, shortly after Commissioner Sadler assumed office, that the State Highway Department laid out the primary highway system which comprises 3,942 mi. and consists of those highways which are of importance to the state at large. The department applied chiefly to the construction of this primary highway mileage the proceeds of the $50,000,000 bond issue authorized by the voters in 1918. In the three years which have elapsed since Commissioner Sadler assumed office, the department, as stated, has put down 1,340 mi. of roadway of such types as with proper maintenance will still be in existence at the maturity of the bonds issued to pay for them. The primary highway system was laid out regardless of divisional lines, such as county boundaries, for the reason that it is of benefit to the state at large, connecting as it does the centers of supply with the centers of consumption.

The types of roadway comprising the 2,776.95 mi. contracted for by the Department since 1903 are as follows:

Type	Miles
Macadam	815.95
Bituminous Macadam	223.46
Brick	156.11
Bituminous Concrete	273.92
Reinforced Concrete	1294.71
Grading and Drainage only	11.54
Plain Concrete	1.26
Total	2776.95

The contract totals from the year 1904 to 1918, inclussive, are as follows: 1904, 69.23 mi.; 1905, 132.39 mi.; 1906, 130.44 mi.; 1907, 209.37 mi.; 1908, 195.77 mi.; 1909, 75.89 mi.; 1910, 48.93 mi.; 1911, 39.29 mi.; 1912, 135.97 mi.; 1913, 63.79 mi.; 1914, 64.62 mi.; 1915, 7.25 mi.; 1916, 21.76 mi.; 1917, 64.71 mi.; 1918, 107.89 mi.

It was during the next three years—1919, 1920 and 1921, that Pennsylvania went into first place in the construction of durable highway. Not only is the record for these three years unequalled by any other American state, but the record of of 670 mi. for 1921 is practically double the mileage of durable roadway put down last year by any other state.

It is the aim of State Highway Commissioner Sadler during the coming season to tie up already constructed sections, insofar as the resources of the department will permit.

Some Unsolved Problems in Highway Economics*

By H. S. FAIRBANK†

To one familiar with the history and interested in the future of American highway building, there is nothing more reassuring—nothing which seems to give better promise of healthy development—than the general recognition of the existence of numerous problems which remain to be solved. At a time not so remote as to be beyond the span of a young man's experience it would have been almost heresy to doubt that the last word had been spoken on the subject of highway design and construction. Highway builders were sure of themselves then—sure of their principles at least—and their main efforts were directed to the standardization of practices to conform to this or that method which had been found successful.

Ante-Bellum Highways

Knowing very little of how they did it, road builders of that day were yet able to build to the full satisfaction of the traffic of the time, a horse-drawn traffic that moved on steel-tired wheels. Then came the automobile to jar the universal complacency and later the motor truck to shatter it to bits, with the war's intensified heavy traffic to grind the bits to powder, then for a season hopelessness, when engineers saw their best roads utterly demolished by trains of army trucks without an idea as to how they were to be replaced.

The New Era

Then came the dawning of the realization that there were some highway problems to be solved, some big problems that go to the very fundamentals of highway engineering. To the Bureau of Public Roads through its contacts with the situation in every corner of our country came the first realization of the bigness of these problems, and it set to work immediately to gather the facts necessary to place highway construction upon a more scientific basis. In this work the bureau has been followed by many of the state highway departments and by the laboratories of a number of universities; and a mass of scientific data has been gathered already which affords a much better insight into the causes of failure and the secrets of highway wear than has ever before been possible.

At first the researches of the various agencies were carried on along the lines which appeared to each as the most desirable and there is no doubt that some of the ground has been covered by more than one investigator with resulting waste of effort. This condition should now be remedied through the instrumentality of the National Research Council, which is undertaking to correlate and coordinate the work of the several agencies, parcelling out to each a definite part of the whole, and knitting together the results of their labors to form a complete fabric of scientifically obtained fact.

Research—Physical and Economic

The researches in which the greatest progress has been made have dealt principally with the physical problems involved in the design of the roads themselves, and certainly our ignorance of the physical properties of subgrade and pavements is sufficient to justify immediate study. But even more important than some of the physical problems are those of an economic nature which condition the character of the physical construction. Before any highway at all can be built these problems must be faced, and by far the majority of considerations influencing the location and type of the road are economic and not physical considerations.

Character of Traffic

Thus, one of the first things that must be known before any highway can be intelligently designed is the character of the traffic it will carry. In this respect the railroad engineer has a relatively simple problem. The traffic he prepares for is more or less definitely predictable. But for the highway engineer the future is cloaked in uncertainty. This much he can be reasonably sure of—that the traffic of the past is no sure index of the traffic of the future. The past use of the road has been governed by its physical condition. When its physical condition is altered the traffic which uses it will change. In a qualitative way it is clear that the future use of the road will depend upon its condition relative to that of other roads serving the same territory. It will also depend upon the character of the towns or cities connected by the road, the distances between them, the nature of the urban and rural industries and the relation of the road's location with respect to steam and electric railroads and navigable waterways. It is not difficult thus to single out the govening factors; the difficulty lies in placing quantitative limits upon each of them.

Traffic Volume and Unit Weight

For purposes of design the engineer must know both the approximate volume of the future traffic and the weight of the heaviest vehicle. Knowledge of the volume of traffic is needed principally to determine the width of the road, the attrition of the surface, a function of volume, being practically negligible when the large majority of vehicles are rubber-tired. The maximum vehicular weight is required to determine the strength of the road surface. In this determination volume plays an unimportant part. It is possible that the repetition of maximum loads may serve to fatigue the road structure and cause it to break down under a load which it would carry safely if applied only occasionally. But, broadly speaking, the road must be designed to carry the heaviest load that will be applied to it, whether that load is applied few or many times.

If this were all the information required, therefore, the economic problem would not be difficult. We could assume with practical certainty that every road—no

*From the "Bulletin" of the Associated General Contractors.

†Senior Highway Engineer, Bureau of Public Roads, U. S. Department of Agriculture.

matter what its location—would occasionally have to carry the heaviest vehicle manufactured, and since the policy of vehicle manufacturers is to restrict weight to a standard maximum, this would not be difficult to determine. As volume of traffic (assuming that it is rubber-tired) has practically no effect upon the design of the surface except as it concerns width, the conclusion would necessarily be that all roads must be constructed of equal strength and that the only permissible variation is in their width.

Light vs. Heavy Traffic

Such a conclusion, while entirely consistent with the physical requirements of unregulated traffic, fails to take account of all the economic facts. Large, heavy vehicles are used in preference to small, light vehicles because their relative cost of operation is lower. One-hundred tons transported in 5-ton vehicles will be moved at lower cost than if it is carried in 1-ton vehicles; but to operate the heavier vehicles requires a heavier and more expensive road. The economic problem, therefore, is to balance the greater cost of the stronger road against the lower operating cost of the heavier vehicle.

To determine how much more can be economically expended to build a road for a traffic of 5-ton instead of 2-ton vehicles the saving in cost of operation per ton-mile must be multiplied by the number of ton-miles carried during the year, and the result will be an annual saving in operation which, capitalized, is the amount that can be spent to strengthen the road to carry 5-ton instead of 2-ton vehicles.

It must be evident, therefore, that if only a few of the heavier vehicles use a given road the saving in operating cost by their use can not be sufficient to justify the additional expense of the stronger road, while if the traffic of such vehicles is large the saving may more than offset the greater construction cost. It appears, therefore, that the facts with regard to traffic that must be known before any intelligent decision as to the type and dimensions of the road can be reached are as follows:

1. The maximum weight of vehicle.
2. The volume of traffic.
3. The relative proportion of heavy and light loads in the traffic.

It is this last named fact that is difficult to determine in advance of construction. In its unimproved condition it is likely that the road has been used by but few heavy vehicles, simply and solely because of its condition. When the condition is improved the chances are that the number of large vehicles that will be operated over it will be increased. How great will be this increase and what expenditure for road improvement will be justified by it is the road builder's problem; and it is a problem that needs a great deal of general and special study.

Regulating Traffic

Unfortunately the uncertainty goes deeper than the mere question of first cost. Supposing that it be decided upon purely financial considerations to build 30 mi. of a given road outward from a city, as a 5-ton road. For that distance, let us say, it is anticipated that the road will carry a sufficient number of 5-ton vehicles to justify the construction of the 5-ton surface. Beyond the 30-mi. point such a showing can not be made and it is decided to provide for vehicles no heavier than 3 tons. What then is to be done about the occasional 5-ton vehicle which it is desired to operate to the town or village 60 mi. from the city? Is its operation beyond the 30-mi. point to be prevented? If so, how is it to be prevented? By police regulation? Then we must take into our financial computations the cost of policing the junctions of heavy and light traffic roads, else assuredly the occasional heavy truck will continue on the light traffic road in defiance of law. Nor have we reached the bottom of the matter yet, for the strict enforcement of such a regulation will mean one of two things either of which will add to transportation costs. Either the cargo of the heavy truck must be transshiped to a lighter vehicle at the junction of the light traffic road or matter destined for points beyond the junction will have to be shipped all the way in light trucks.

All this involves loss in operating cost. To build all roads for the heaviest units, which is practically the alternative, means waste in road construction, in that the cost of strengthening a large part of the system will never be repaid by the saving in operating expense resulting from the use of the few heavy vehicles that will ply over that part. Which way does economy lie?

Operating Costs

The question will never be definitely answered except in connection with the special conditions surrounding each case, but there are a number of general questions, which will arise in every case, which deserve immediate attention by those who are working to solve the newly recognized highway problems. Such matters as the operating cost of motor vehicles; the economic motor-truck haul in competition with steam and electric and waterway transportation, and in the absence of such competition; the highway traffic contributions of the principal industries; the relation of cities and the distance between them to the character of highway traffic—these are matters requiring general study for application to particular cases. In view of their manifest importance it is difficult to understand why they have not already received the careful, scientific study that is being given to the solution of the more important physical problems.

A DELAWARE APPRECIATION OF THE DU PONT BOULEVARD

The subjoined verse from the Delaware State Highway Department, author not specified, probably reflects the sentiments of many an automobilist.

A Tribute

When we plow through mud, after heavy rains,
And the auto bumps, and grinds, and strains,
We think of smooth and hard-surfaced roads
Where cars glide along with heavy loads.
We also think of one determined man,
Who stuck with courage and grit to a plan,
Never halted a whit through slander and taunt;
We praise the name of COLEMAN du PONT.
We're pleased to have this word to say
For the man, as well as for the beneficient way,
He has helped our state, with no selfish trace,
And made for us all a much better place.

MEETINGS

Calendar of Coming Meetings

Jan. 12-14—Highway Engineers' Association of Missouri—Annual meeting, Kansas City, Mo.

Jan. 17-19—Iowa Engineering Society.—Thirty-fourth Annual Meeting, Sioux City, Iowa. Secretary, L. A. Canfield, Des Moines, Ia.

Jan. 17-19—Associated General Contractors of America—Third Annual Meeting, Hotel Winton, Cleveland, Ohio. General Manager, R. C. Marshall, Jr., 1038 Munsey Bldg., Washington, D. C.

Jan. 17-20, 1922—American Road Builders' Association.—Nineteenth Annual Convention, Twelfth American Good Roads Congress and Thirteenth Good Roads Show under the auspices of the A. R. B. A., The Coliseum, Chicago, Ill. Secretary, E. L. Powers, 11 Waverly Place, New York, N. Y.

Feb. 12-17—Conference on Highway Engineering.—Eighth Annual Conference, University of Michigan, Ann Arbor, Mich.

AMERICAN SOCIETY OF CIVIL ENGINEERS

The annual meeting of the American Society of Civil Engineers will be held on Jan. 18 in the auditorium of the Engineering Societies Building in New York City. On the following two days, Jan. 19 and 20, a conference will be held on national transportation problems. The first day will be devoted to a discussion of water and railroad transportation and the last day to highway transportation.

HIGHWAY ENGINEERS' ASSOCIATION OF MISSOURI

The fifteenth annual meeting of the Highway Engineers' Association of Missouri will be held on Jan. 12, 13 and 14 at the Baltimore Hotel, St. Louis, Mo. Among the papers which will be read are "Bituminous Roads," by Robert W. Waddell, City Engineer, Kansas City, Mo.; "Oiling Roads," by Leo E. Koehler, Highway Engineer, Jackson County; "Road Building Materials," by H. A. Buehler, State Geologist; "Federal Aid," by H. H. Lotter, Senior Highway Engineer, Bureau of Public Roads; "Brick Roads, Their Construction and Maintenance," by M. W. Watson, State Highway Engineer of Kansas; "The Problem of Heavy Trucks and Permanent Highways," by E. J. McCaustland, Dean, University of Missouri; "The Bates Experimental Road and Problems of Design, Construction and Maintenance," by Clifford Older, State Highway Engineer of Illinois; "Construction and Maintenance of Concrete Roads," by John M. Malang, former State Highway Superintendent of Missouri; "Gravel Roads, Their Construction and Maintenance," by C. Coykendall, Assistant State Highway Engineer of Iowa; "Testing Work of Bureau of Public Roads, Its Aims, and Results Obtained," by E. B. Smith, Bureau of Public Roads; "Road Laws of Missouri," by Walter E. Bailey, Chairman, Road Committee, Missouri House of Representatives; "Resume of the Work Done by the State Highway Department," by Alexander W. Graham, State Highway Engineer of Missouri.

WOOD PRESERVERS INITIATE STUDY OF CREOSOTED BRIDGE FLOORS

A joint committee consisting of representatives of wood preserving, fire protection, bridge engineering and lumber interests has been formed under the auspices of the American Wood Preservers' Association to study creosoted wood bridge floor construction.

Numerous bridge fires have led to the supposition that improper design probably plays a part in such cases. Since wood floors will be used and the wood will be treated to resist decay, the committee will make an exhaustive study of the entire subject.

The members of the committee are: L. T. Ericsen, of the Jennison-Wright Co., chairman; E. F. Kelley, of the bridge division of the Bureau of Public Roads; Geo. W. Booth, Chief Engineer of the National Board of Fire Underwriters, and D. F. Holtman, of the National Lumber Association.

PERSONAL MENTION

P. C. McArdle has resigned as superintending engineer for Vermilion County, Illinois, the bond issue road system upon which he has been engaged having been completed.

V. W. Baise has been promoted from draftsman and computer to assistant engineer in the department of highway designs and estimates of the North Carolina State Highway Department.

J. R. McDermott has been appointed a resident engineer with the West Virginia State Roads Commission. He will have charge of work in Mineral and Hampshire Counties, with headquarters at Keyser. Mr. McDermott was formerly an assistant division engineer.

PUBLICATION

MANUAL ON ROAD CONSTRUCTION. Division of Highways, Illinois. Prepared by B. H. Piepmeier, Engineer of Construction, Division of Highways. Paper, 6x9 in., 73 pages. Illustrated.

This manual, setting forth the requirements of the Illinois Division of Highways in the construction of various types of roads, was prepared for the use of resident engineers and inspectors. About half of the book is devoted to concrete pavements, the remainder of the book being given to the consideration of other types of roads and instruction in the details involved in the supervision of road work.

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CONSTRUCTION TRANSPORTATION MAINTENANCE

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TABLE OF CONTENTS

*Survey of Road Work in Illinois. By Clifford Older 11
*Thirteenth National Good Roads Show 14
Traffic and Transportation 20
*The American Road Builders' Association and its Chicago Convention 23
Government Sees Solution of Heavy Motor Truck Problem 28
*Subgrade Drainage Tests Yield Interesting Preliminary Data. By Ira B. Mullis 29
Airship photographs for City and Highway Surveys 33
Asphalt Paving in 1921 33
Four Years' Highway Work in the State of Pennsylvania 34
Federal Aid Projects Approved 34
Engineers Adopt Final Plans for the Lincoln Highway "Ideal" Section 36
Parking Tunnels Suggested for New York City . 36

EDITORIAL:

The Convention at Chicago 21

EQUIPMENT—TRADE-MATERIALS:

New Bulletin on Snow Removal 35
*New Ingersoll-Rand Compressor 35
*Truck Operated Profitably in Road and Excavation Work 35
*White Builds New Business Car 36

MEETINGS:

Calendar 37
Standardization of Paving Brick 37
Wisconsin Road School 38

PERSONAL MENTION 38

PUBLICATION 38

*Illustratd articles

Concrete Roads must be Reinforced

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They build good roads to start with and then, by far-sighted but inexpensive maintenance with "Tarvia-B," make those good roads better every year.

This extract from their letter will be of interest to all highway officials:

> "Our experience in successfully maintaining our macadam roads with "Tarvia-B" is due not only to the excellence of your product, but also to the rule we follow in Columbia County of surface treating macadam roads in good condition and giving them additional treatments of Tarvia annually.
>
> "During the past couple of years, we have used clean limestone screenings ¾" size as a covering after applying the Tarvia. We believe we are adding just a little more Tarvia surface each year than the traffic wears off, as we have several macadam roads in this county that have been annually treated with "Tarvia-B" for the past six years and are in better condition at the present time than they were when first treated with Tarvia."

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THE HIGHWAY CONTRACTOR AND ROAD BUILDER

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Survey of Road Work In Illinois

By CLIFFORD OLDER*

The road program of the State of Illinois embraces approximately 5,000 mi. (to be improved by the state) out of a total road mileage of about 96,000 mi. exclusive of the streets of corporate cities and villages. Of these 5,000 mi. above mentioned, 1,200 mi. have already been completed—at a total cost of about $30,000,000.

While many of the contracts for this work were awarded in 1919, the greater part of the actual construction was concentrated in the years 1920 and 1921, 400 mi. having been built in 1921. During the past few months contracts have been awarded for a large amount of additional paving work, which, together with uncompleted contracts having been previously awarded, amounts to about 550 mi. of paving construction carried over to next season. In addition, several hundred miles of heavy grading contracts have been awarded in locations where fills must be allowed to settle a year or more before paving may safely be constructed.

The completed construction work above outlined has been accomplished without the expenditure of any of the funds provided by the sixty million dollar bond issue which was approved by the people of this state in Novem-

*Chief Highway Engineer of Illinois.

SHERIDAN BRIDGE OVER FOX RIVER NEAR SHERIDAN IN LASALLE COUNTY. REINFORCED CONCRETE ARCHES—FOUR SPANS AT 55 FT. EACH.

ber, 1918. The funds so far used have been provided by federal aid allotments to Illinois which have been met by state appropriations made from motor license fee collections. The state therefore has available the entire amount of the bond issue and will in addition, no doubt, have available considerable sums from federal aid appropriations, which may be met by motor license fee collections without jeopardizing the retirement of the bonds which must also be made from the same source

Organization

The highway work in Illinois is carried out under the general direction of Governor Len Small through the Division of Highways of the Department of Public Works and Buildings. The Division of Highways is but one of the activities of this department, of which Cornelius R. Miller is director. The Division of Highways is under the direction of Frank T. Sheets, State Superintendent of Highways, and Clifford Older, Chief Highway Engineer.

For purposes of administration, the work of the division is divided into several bureaus; namely, the Bureau of Audits, Bureau of Design (which is further divided into the road office and the bridge office under the direction of a road engineer and a bridge engineer respectively), the Bureau of Construction; Bureau of Maintenance, Bureau of Tests, and Bureau of Machinery. The functions of these bureaus are briefly as follows: The Bureau of Audits, under J. M. McCoy, chief clerk, handles all accounting and other clerical work; the Bureau of Design, under H. E. Surman, Engineer of Design (V. L. Glover, Road Engineer and George F. Burch, Bridge Engineer) handles all of the activities of the Division of Highways relating to roads and bridges from the time work is instituted until contracts are awarded. This includes the supervision of all right of way purchases and records, as well as the preparation of plans and giving consulting advice to township and county officials on road and bridge work. The road office and bridge office perform these functions under the direction of the Engineer of Design; The Bureau of Construction, under B. H. Piepmeier, Engineer of Construction, has supervision of all of the construction activities of the Division of Highways including the supervision of the construction activities carried on by the various counties under the provisions of the law requiring supervision of such work by the state; the Bureau of Maintenance, under Fred Tarrant, Maintenance Engineer, is charged with the duties of maintaining all of the roads for which the state is responsible; the Bureau of Tests under H. F. Clemmer, Testing Engineer, is charged with the duties of the inspection of the construction materials entering into road and bridge work, both for the state and counties and townships as well; in addition this bureau carries out the investigational and research work of the division; the Bureau of Machinery, under D. B. Cornell, Superintendent of Machinery, is charged with the duties of receiving, storing, maintaining and operating all surplus war machinery received from the U. S. Government as well as other equipment owned by the Division of Highways.

For the purpose of handling construction and maintenance work in detail, the state has been divided into nine districts, having approximately equal areas, with a district engineer in charge of each district. The district engineer directs all of the activities in his district and reports to each of the various bureau chiefs in accordance with the nature of the work involved.

At the present time we have a total of 590 employes in the division.

Under this organization, the Division of Highways has been able to efficiently administer and supervise the entire construction program at a cost amounting to approximately 4.35 per cent of the total expenditures.

Construction Costs

A general idea of the downward trend of road construction costs since the first letting this year, held in February, 1921, may be gained from the fact that the price of pavement at that time averaged $2.36 per square yard without cement, whereas at the letting held on October 4, 1921, the price per square yard averaged

SHOWING GRADE SEPARATION UNDER THE SANTA FE RAILROAD

COMPLETED PAVEMENT ON DIXIE HIGHWAY SHOWING EASY CURVES.

$1.70 without cement. The average cost per mile for concrete pavement, including cement, was $39,120 on February 18; and on October 4 this was reduced to $28,540 per mile. Excavation prices have been reduced from 56 ct. per cubic yard average price on February 18 to 26 ct. per cubic yard average price on October 4. Class A concrete has been reduced from $26.29 per cubic yard on February 18 to $16.83 per cubic yard on October 4. A comparison of these same lettings shows that reinforcing steel has been reduced from 6.1 ct. per pound to 3.94 ct. per pound; and structural steel from 7.7 ct. per pound to 5.2 ct. per pound.

Construction Conditions in 1921

During 1921 the efficiency of all paving construction outfits increased markedly over that of the previous few years. No difficulty was encountered in securing the rapid transportation of materials; and labor efficiency increased decidedly. There were 95 different paving contractors operating in the state and a total of 102 paving mixers at work. In addition, there were 49 bridge contractors and 39 grading contractors operating. A total of 283 independent paving, grading and bridge sections were involved in this work. In addition to the 400 mi. of pavement completed during the past season, 3,000,000 cu. yd. of earth were moved and approximately 45 separate bridges built. The greatest length of pavement laid in any one day by one mixer was 1,434 ft. The greatest week's record for any one mixed was 5,780 ft.; and the best week's record for all the contractors in the state was 19.35 mi.

The plentiful supply of labor permitted a number of contractors to work double shifts and it is gratifying to know that night work was satisfactory both from the point of view of the contractor and the Division of Highways.

Maintenance

The Maintenance Bureau is based on the patrol system. Patrolmen are established as rapidly as heavy grading and paving work are completed. On completed heavy grading work patrol sections are from six to ten miles long. On paved roads the patrol sections average about twenty miles in length; and each patrolman on the paved sections is supplied with a 2-ton truck as well as small tools. Our experience indicates, however, that this equipment is not well balanced and is too cumbersome for this class of maintenance work. In all probability, paved road patrol sections will be reduced in length, and the patrolmen will be equipped with very light trucks and small tools. Maintenance work on our paved sections, which are practically all constructed of concrete or other rigid types, consists chiefly of keeping the shoulders up to grade, cutting weeds, cleaning ditches, filling cracks, etc. Heavy trucks or other heavy equipment are not therefore much needed. The Maintenance Bureau is charged with the duty of erecting and maintaining traffic, directory and warning signs. The route numbering system has been adopted as the basis of directory signs. In addition to the number of the route at each cross road there will be a mile number which, by reference to a map of the route, will indicate to the tourist the exact location of each cross road. Conspicuous warning, caution and danger signs are being erected at all curves, cross roads and other places where the attention of the general public should be called to features of potential danger. The system of warning signs in use was adopted only after careful study and observation of a stretch of 60 mi. of road along which a tentative system was tried out.

Research Work

No small part of the energy of the engineering department of the Division of Highways has been devoted to research work; the object being not only the improvement of pavement types in order that modern traffic may be carried at the least expense, but also with a view to determining methods which may be adopted to reduce construction and maintenance costs.

Research work carried out in connection with the Bates Experimental Road, which has been described previously in GOOD ROADS, has led to important modifications in pavement designs used by the Division of Highways. It is believed that the results of these scien-

(Continued on page 22)

SHOWING GUTTER SECTIONS THROUGH DEEP CUTS

SPRINGFIELD-PEORIA ROAD NORTH OF SPRINGFIELD

The Thirteenth National Good Roads Show

Directory of Exhibits of Road Building Machinery, Materials and Methods in the Coliseum, the Greer Annex and the Wilson Annex

The Thirteenth National Good Roads Show, to be held under the auspices of the American Road Builders' Association in connection with that organization's nineteenth annual convention, will doubtless prove to be the greatest exhibition of its kind ever held up to this time. As in previous years, it will comprise displays of road building equipment and materials in almost endless variety, as well as exhibits depicting methods of testing, of construction and maintenance. In numbers, also, it bids fair to surpass all previous shows, exhibitors having been assigned space at this writing, more than a week before the opening of the show.

The Coliseum, which served so admirably for last year's exhibition, will be utilized next week and, in addition, there will be displays in the gallery of the Coliseum and in the Greer Annex and the Wilson Annex, two buildings adjoining the Coliseum on the south.

In the following paragraphs are listed the exhibitors, with the numbers of their exhibition spaces and a brief, partial list of the displays. Numbered plans of the exhibition floors are shown on three of the following pages.

While this directory can not include those who may be assigned space or whose assignments may be changed after this goes to press, it will be found correct for the great majority of the exhibitors. The location of those not listed here can be obtained by application to the information bureau.

Acme Road Machinery Co., Frankfort, N. Y., No. 228. Photographs of the Acme line of road building equipment, and literature.

J. D. Adams & Co., Indianapolis, Ind., No. 78, Gallery. Motion pictures showing Adams adjustable leaning wheel graders and maintenance machines.

American Casting Co., Birmingham, Ala., Nos. 269 and 270. National lock-joint cast-iron culvert pipe of various diameters.

American Gas Accumulator Co., Elizabeth, N. J., No. 1, Gallery. Highway warning lights and literature.

American Highway Educational Bureau, Washington, D. C., No. 4, Gallery. Literature.

American Refractories Co., Pittsburgh, Pa., No. 10, Gallery. Road and pavement aggregates.

American Steel and Wire Co., Chicago, Ill., No. 6, Gallery. Triangle mesh concrete reinforcement for highways and all forms of concrete construction.

American Tar Products Co., Chicago, Ill., No. 83, Gallery. Photographs and literature.

American Wood Preservers', Service Bureau, Chicago, Ill., No. 5, Gallery. Models, samples, photographs and literature.

Anthony Company, Inc., Streator, Ill., No. 68, Gallery. Automatic rocker dumping body for Ford truck, with open seat.

The Asphalt Association, New York, N. Y., Nos. 26 and 27. Road models, pavement cross-sections, samples of materials, diagrams and literature. Motion pictures.

Asphalt Paving Retreading Co., Chicago, Ill., Nos. 4, 5 and 6, Greer Annex. Literature.

Atterbury Motor Car Co., Buffalo, N. Y., Nos. 161, 162, 181 and 182. Two Atterbury contractors' special trucks.

The Austin-Western Road Machinery Co., Chicago, Ill., Nos. 40-46 and 64-70. One 10-ton Austin motor roller, with attached scarifier; one Austin twin-cylinder motor roller; one Austin steam roller; one Austin block scarifier; one Austin motor sweeper; one Austin "Rip Snorter"; one Western No. 20 grader; one Little Western grader; one Western Auroral crusher, No. 2; one Western wheeler; one Western No. 7 plow; one Western locomotive plow; one Western Fresno scraper; one Western drag scraper; one Western ditcher and back sloper; Austin culverts.

The Autocar Co., Ardmore, Pa., Nos. 115 to 118 and 139 to 142. One Autocar chassis with low side rotary dump body; one chassis with 2½-yd. rotary dump body; one chassis with combination rotary dump body.

The Avery Company, Peoria, Ill., No. 9 Wilson Annex. Avery one-man "Road-Razer," with scarifier attachment.

Baldwin Chain & Mfg. Co., Worcester, Mass., No. 262. Sprockets and roller chains; malleable chains; malleable castings.

Ball Engine Co., Erie, Pa., No. 49, Gallery. Models of engines and literature.

The Barber Asphalt Paving Co., Philadelphia, Pa., Nos. 159, 160, 179 and 180. Iroquois macadam roller and other road building machinery; Trinidad and Bermudez asphalt.

The Barber-Greene Co., Aurora, Ill., Nos. 192 and 193. Self-feeding bucket loader; motion pictures.

Barnes Manufacturing Co., Mansfield, O., No. 282 and 283. Portable power pumps and literature.

The Barrett Co., New York, N. Y., Nos. 229 and 230. Samples of Tarvia; model of Tarvia distributor; lantern slides, photographs and moving pictures.

Beach Mfg. Co., Charlotte, Mich., No. 227. Hoisting engine; bottomless bucket in operation with dragline; "Ever Clean" gravel screen in operation.

Blaw-Knox Co., Pittsburgh, Pa., Nos. 106, 107, 108, 130, 131 and 132. Road, sidewalk, and curb and gutter forms and accessories; truck turntable; storage bin and batcher; buckets; truck body; sectional steel building.

Brown Hoisting Machine Co., Cleveland, Ohio, Nos. 7, 8, 23, 24 & 25. Brownhoist No. 2 locomotive crane with attachments for road work.

The Buda Co., Harvey, Ill., No. 98 Gallery. Models and literature.

The Burch Plow Works Co., Ashland, Co., No. 89, Gallery. Plows and literature.

The Byers Machine Co., Ravenna, Ohio, Nos. 247 to 253. One revolving crane one Model 4 auto crane.

Cabell Petroleum Co., St. Louis, Mo., No. 109. Samples of road oil and literature.

Carbic Manufacturing Co., Chicago, Ill., No. 40, Gallery. Carbic acetylene lights and carbic cakes.

The Philip Carey Co., Cincinnati, O., No. 176. Samples, literature and models.

Chain Belt Co., Milwaukee, Wis., Nos. 123 to 126 and 147 to 150. Rex 21E paver; Rex 28S building mixer.

Clark Tructractor Co., Buchanan, Mich., Nos. 173 and 174. Clark tructractor.

Clay Products Association, Chicago, Ill., No. 34, Gallery. Literature.

Climax Engineering Co., Clinton, Ia., No. 64, Gallery. Climax engines and literature.

Columbian Steel Tank Co., Kansas City, Mo., No. 281. Models and literature.

Concrete Steel Co., New York City, Nos. 212A and 213B. (These spaces not shown on chart.) Samples of reinforcing steel and literature.

The F. D. Cummer & Son Co., Cleveland, Ohio, No. 27. Catalogs and literature.

Domestic Engine & Pump Co., Shippensburg, Pa., Nos. 214 and 215. Portable force pumping engines for road work; Domestic trench force pumper.

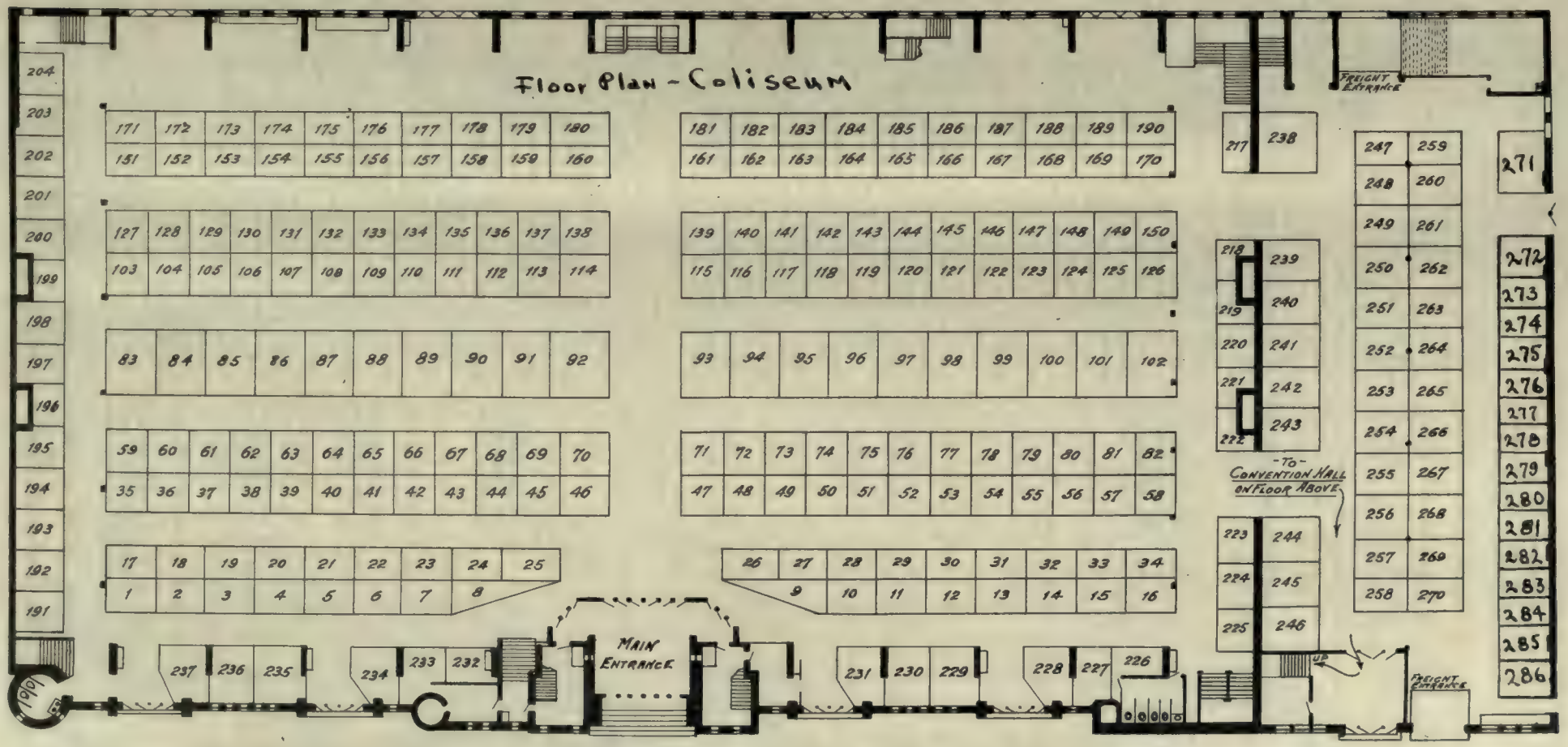
Dunn Road Machinery Co., Conneaut, Ohio, Nos. 57, 58, 81 and 82. Automatic template tamping and finishing machine.

Dunn Wire-Cut Lug Brick Co., Conneaut, Ohio, Nos. 57, 58, 81 and 82. Wire-cut lug paving brick.

Earth Concrete Co., Grand Rapids, Mich., No. 216. Samples of earth concrete and "claycrete" from roads; samples of "earthcrete"; photographs.

The East Iron & Machine Co., Lima, Ohio, No. 231. Model of Merriman asphalt plant; photographs; literature.

Easton Car & Construction Co., Easton, Pa., No. 74, Gallery. Road builders' 2 and 3-box batch cars; batch boxes; portable



Floor Plan—The Coliseum

track; gravity end-dump truck bodies; models; photographs.

Electrical & Specialty Supply Co., Chicago, Ill., No. 213. Mushroom traffic lights mushroom zone markers; photographs.

Electric Wheel Co., Quincy, Ill., No. 35, Gallery. Models and literature.

"Engineering and Contracting," Chicago, Ill., No. 200. Copies of publication.

"Engineering News-Record," New York City, No. 203. Copies of publication.

The Erie Steel Construction Co., Erie, Pa., No. 69, Gallery. Working model, photographs and blueprints of the Erie Aggre-Meter plant.

Equipment Corporation of America, Chicago, Ill., Nos. 271, 272 and 283. Concrete mixers for road, bridge and culvert work; steam hoisting engine; steam road roller; clamshell bucket; gasoline hoist; pump.

The Fate-Root-Heath Co., Plymouth, Ohio, Nos. 5, 6, 20 and 21. Two gasoline industrial locomotives.

The Four Wheel Drive Auto Co., Clintonville, Wis., Nos. 114 and 138. Truck and body truck units.

The Galion Iron Works & Mfg. Co., Galion, Ohio, Nos. 3, 4, 19, 20, 235 and 236. Motor road roller; Giant Premier road grader; Universal stone and gravel spreader; moving pictures.

General Motors Truck Co., Pontiac, Mich., Nos. 5 and 6, Wilson Annex. One 2½-ton GMC motor truck chassis with dump body; one GMC unit power plant.

"Good Roads," New York City, No. 196. Copies of publication.

The Good Roads Machinery Co., Kennett Square, Pa., Nos. 16 and 17, Wilson Annex. Winner highway patrol grader; Killefer scarifier; Winner road drag; corrugated metal culvert pipe.

L. P. Green, Chicago, Ill., Nos. 274 and 275. Power drag scrapers; models.

Frederic Greer, Chicago, Ill., No. 287. Two-wheeled 3-ton trailers.

W. & L. E. Gurley, Troy, N. Y., No. 62, Gallery. Engineering and surveying instruments; hydraulic engineering instruments.

The Hadfield-Penfield Steel Co., Bucyrus, Ohio, Nos. 232, 233 and 234 and 13 and 14, Wilson Annex. American gasoline locomotives; tractors.

Handy Sack Baler Co., Cedar Rapids, Ia., No. 41, Gallery. Model of empty cement sack baler and literature.

The Hastings Pavement Co., New York City, No. 97, Gallery. Samples of asphalt paving blocks and literature.

The Heil Co., Milwaukee, Wis., Nos. 211 and 212. Miniature truck equipped with Heil hoist and dump body; gravity bodies; welded tanks.

The Heltzel Steel Form & Iron Co., Warren, Ohio, No. 75, Gallery. Steel road, sidewalk, curb, and curb and gutter forms; hand tamping machine.

Hetherington & Berner, Inc., Indianapolis, Ind., No. 204. Photographs and literature.

"Highway Engineer and Contractor," Chicago, Ill., No. 205A. (Space not shown on chart). Copies of publication.

The Highway Trailer Co., Edgerton, Wis., Nos. 52 and 53, Gallery. Bodies and hoists.

The Holt Manufacturing Co., Peoria, Ill., Nos. 47-56 and 71-80. Three 5-ton Caterpillar tractors; three 10-ton Caterpillar tractors; Caterpillar "bulldozer" attachment; Caterpillar snowplow; Caterpillar winch attachment.

Hough Mechanical Hoist Co., Chicago, Ill., Nos. 65 and 66, Gallery. Model of hoist and literature.

The Hug Co., Highland, Ill., Nos. 1, 2 and 3, Wilson Annex. Hug special speed truck and literature.

Chas. Hvass & Co., Inc., New York, N. Y., Nos. 110 to 113 and 133 to 137. Portable asphalt plant; bitumen distributors; trailer sweeper; spreader; heating kettles; scarifier; sprinkler; automobile flusher push brooms.

Hyatt Roller Bearing Co., New York, N. Y., No. 55, Gallery. Samples of various types and sizes of Hyatt bearings and descriptive literature and photographs showing installations of road building and contractors' equipment in which Hyatt bearings are employed.

Indiana Truck Corporation, Marion, Ind., No. 19, Wilson Annex. Motor truck and literature.

Industrial Works, Bay City, Mich., No. 33, Gallery. Model of tractor crane and literature.

International Motor Co., New York, N. Y., Nos. 87, 88 and 89. One Mack-Cressy road sprayer; one 2-ton AB Mack road building truck; one 2-ton AB Mack road building truck (shorter wheelbase).

International Steel Tie Co., Cleveland, O., No. 9, Gallery. Samples and literature.

Jennings Automatic Dump Body, Inc., Roanoke, Va., No. 226. Models of motor truck dump bodies.

The Jennison-Wright Co., Toledo, O., No. 7, Gallery. Samples of wood paving blocks and literature.

The J. T. Tractor Co., Cleveland, Ohio, No. 259. Tractor.

Kentucky Rock Asphalt Co., Louisville, Ky., No. 63, Gallery. Samples of rock asphalt and literature.

Keuffel & Esser Co., New York, N. Y., No. 42, Gallery. Surveying, drawing and mathematical instruments.

Keystone Driller Co., Beaver Falls, Pa., Nos. 254 to 258. Model No. 4 Keystone traction steam shovel, with skimmer and ditcher scoops.

Kinney Mfg. Co., Boston, Mass., No. 67, Gallery. Kinney heater and distributor and Kinney pumps.

Kissel Motor Car Co., Hartford, Wis., Nos. 90, 91 and 92. Special road builders' truck; Quartersize working models of special road truck, turntable, gravel and sand loading hopper and measuring boxes, cement hopper with measuring box.

Koehring Co., Milwaukee, Wis., Nos. 93 to 102. One 15-ton crane-excavator; one 21-E paving mixer; one 7-E paving mixer; one 107-S Dandie mixer.

Koppel Industrial Car & Equipment Co., Chicago, Ill., No. 3 Greer Annex. Road builders' track and car equipment, and batch boxes.

The Lakewood Engineering Co., Cleveland, Ohio, Nos. 11 to 16 and 29 to 34. Paving mixer; road finisher; subgrader; narrow gauge track; batch box cars; batch boxes; gasoline locomotive; road forms; grout mixer; clamshell bucket.

Lee Trailer & Body Co., Chicago, Ill., Nos. 165 to 168. Motor truck dumping bodies; motor truck trailers.

Le Roi Company, Milwaukee, Wis., Nos. 177 and 178. Engines and power units.

The F. J. Lewis Manufacturing Co., Chicago, Ill., No. 284. Samples of coal tar paving materials and of pavements built of them; literature.

Littleford Bros., Cincinnati, Ohio, Nos. 38, 39, 62 and 63. Andresen road repair outfit; Littleford portable tar asphalt heaters, maintenance heaters, pouring pots and paving tools.

The Locomotive Crane Co. of America, Champaign, Ill., Nos. 244, 245 and 246. Little Giant road crane equipped with Elseeco endless tread and Elseeco grab.

"Manufacturers Record," Baltimore, Md., No. 209A, (Space not shown on chart.) Sopies of publication.

The Maxon Co., Milwaukee., Wis., Nos. 169, 170, 189 and 190. Concrete road finishing machine.

Metal Forms Corporation, Milwaukee, Wis., No. 118. Road rails and culvert forms.

Milwaukee Locomotive Mfg. Co.; Milwaukee, Wis., Nos. 152 to 154. Road building gasoline locomotive.

Monarch Tractors, Inc., Watertown, Wis., Nos. 263, 264 and 265. Tractors and snow plow.

Morand Cushion Wheel Co., Chicago, Ill., No. 99, Gallery. Literature.

National Paving brick Manufacturers' Association, Cleveland, O., Nos. 207 and 208. Samples of paving bricks and literature.

National Steel Fabric Co., Pittsburgh, Pa., No. 11, Gallery. Steel fabric reinforcing material.

Northwest Engineering Co., Green Bay, Wis., No. 238. Northwest crawler crane; motion pictures.

Novo Engine Co., Lansing, Mich., Nos. 156, 157 and 158. Gasoline engine; gasoline engine driven hoist equipment; gasoline engine driven pumping outfit; gasoline engine driven portable compressor outfit.

Oliver Chilled Plow Works, South Bend, Ind., No. 23, Wilson Annex. Contractors' plows and literature.

The Osgood Company, Marion, Ohio, Nos. 279 and 280. Photographs and literature.

Oshkosh Manufacturing Co., Oshkosh, Wis., Nos. 1, 2, 17 and 18. One 14E Oshkosh paver.

Parker Motor Truck Co., Milwaukee, Wis., Nos. 194 and 195. One 3½-ton truck.

Pawling & Harnischfeger Co., Milwaukee, Wis., Nos. 143 to 146. A No. 206 Corduroy gas engine driven shovel with skimmer boom attachment; contractors' hoist; photographs.

Pioneer Asphalt Co., Lawrenceville, Ill., No. 198. Samples of expansion joint and asphalt filler for brick pavements; literature.

"Pit and Quarry," Chicago, Ill., No. 8, Gallery. Copies of publication.

Portland Cement Association, Chicago, Ill., No. 86. Photographs; charts; literature.

"Public Works," New York City, No. 201. Copies of publication.

Ransome Concrete Machinery Co., Dunellen, N. J., Nos. 239 to 243. One 21-E paving mixer, on Marion crawling traction; one 7-S Standard building mixer.

Reo Motor Car Co., Lansing, Mich., Nos. 161, 181, 184 and

Floor Plan — Coliseum Gallery

186. One "carryall" truck; one speed wagon with dump body and road floater.

Republic Truck Sales Corporation, Alma, Mich., Nos. 35 to 37 and 59 to 61. One "rapid transit" truck; one "road builder" truck; one "good roads maintenance" truck; one "contractor" truck.

Sauerman Bros., Chicago, Ill., Nos. 117 to 122. Working models of cableway excavators and bottomless power scrapers; accessories for cableway and scraper systems.

The G. A. Schacht Motor Truck Co., Cincinnati, Ohio, Nos. 151 and 171. A 4-ton speed truck with dump body.

Chris D. Schramm & Son, Inc., West Chester, Pa., Nos. 276 and 277. Two portable, engine driven air compressor outfits with rock drilling equipment; one portable, engine driven road pump.

The Seibert-Milburn Co., Columbus, Ohio, No. 261. Lee concrete road finisher; Owen clamshell bucket.

The T. L. Smith Co., Milwaukee, Wis., No. 8. Paving mixer; concrete mixer.

Standard Oil Co. (Indiana), Chicago, Ill., Nos. 9, 10 and 28. Mechanical oil farm; samples of asphalt and road oil; photographs; literature.

Stoughton Wagon Co., Stoughton, Wis., Nos. 7 and 8, Wilson Annex. One Model F, 3-ton truck with dumping equipment; one Model D 2-ton dump truck.

Stroud & Co., Omaha, Neb., No. 260. Road maintainer.

The Texas Company (Asphalt Sales Department), New York, N. Y., Nos. 209 and 210. Samples of asphalt and road oils; literature.

The Thew Shovel Company, Lorain, Ohio, No. 286. Photographs and literature.

Thompson Bros. Co., Chicago, Ill., No. 3, Gallery. Literature.

Titan Truck Co., Milwaukee, Wis., Nos., 186, 187 and 188. Special subgrade truck.

Truscon Steel Co., Youngstown, O., Nos. 205 and 206. Samples of road reinforcing and literature.

The W. S. Tyler Co., Cleveland, Ohio, Nos. 223 to 225. A "hum-mer" electric screen; Tyler screen scale testing sieves; "ro-tap" testing sieve shaker; woven wire screens.

Van Dorn Iron Works, Cleveland, O., No. 56, Gallery. Samples and literature.

Waukesha Motor Co., Waukesha, Wis., No. 185. One industrial unit; one sectional motor (cut away).

Western Wheeled Scraper Co., Aurora, Ill., Nos. 155 and 175. Road builders' car and batch boxes; photographs.

The Geo. D. Whitcomb Co., Rochelle, Ill., No. 7, Greer Annex. One 6-ton gasoline locomotive; skeleton of transmission; parts of locomotive.

The White Company, Cleveland, Ohio, Nos. 83 to 85. A 2-ton power dumping truck; pressure distributor; models; posters.

Wiard Plow Co., Batavia, N. Y., No. 172. Road plows.

Wisconsin Motor Mfg. Co., Milwaukee, Wis., Nos. 266 and 267. Gasoline engines.

Wood Hydraulic Hoist & Body Co., Detroit, Mich., Nos. 103 to 105 and 127 to 129. Hoists and dump bodies.

The Wyoming Shovel Works, Wyoming, Pa., No. 43, Gallery. Red Edge shovels, scoops and picks.

GRADE CROSSINGS ON FEDERAL AID ROADS TO BE ELIMINATED

Grade crossings will be eliminated wherever possible on the roads of the federal aid highway system, which will be built as a result of the passage of the Federal Highway Act. When the roads which form the primary or interstate system are constructed, no grade crossing will be allowed to remain that it is at all practicable to avoid. Every effort will be made to make the roads of the secondary system equally safe, but in this case it is recognized that elimination may not be practicable in all cases at this time.

In making this announcement the Bureau of Public Roads, under whose supervision the fund is allotted and construction is undertaken, is putting into effect a policy which it has long advocated in principle, and whose adoption it has urged with increasing effectiveness upon state highway officials for some time past. The policy is meeting with hearty cooperation on the part of the states, and the American Association of State Highway Officials by resolution has pledged its best efforts to cooperate to eliminate grade crossings on new construction.

In addition, the policy finds favor among the railroads, some of the leading carriers already having lent cheerful aid in avoiding the construction of more grade crossings.

Instead of grade crossings there will be constructed, wherever possible, in the future either a bridge or an underpass where roadway and railway intersect. Important roads, which now cross and recross railroad lines at grades hereafter will be located entirely on one side of the railroad, even though to do so may increase the cost of construction. State officials, realizing the need of eliminating grade crossings, have stated their desire to cooperate with the department in carrying out this plan.

Where crossings are unavoidable, or where local interests justify construction of highways to cross railroad lines, the road will be so located as to pass over the track or under it. In most instances of this sort the railroads bear one-half of the cost of building the bridge or underpass.

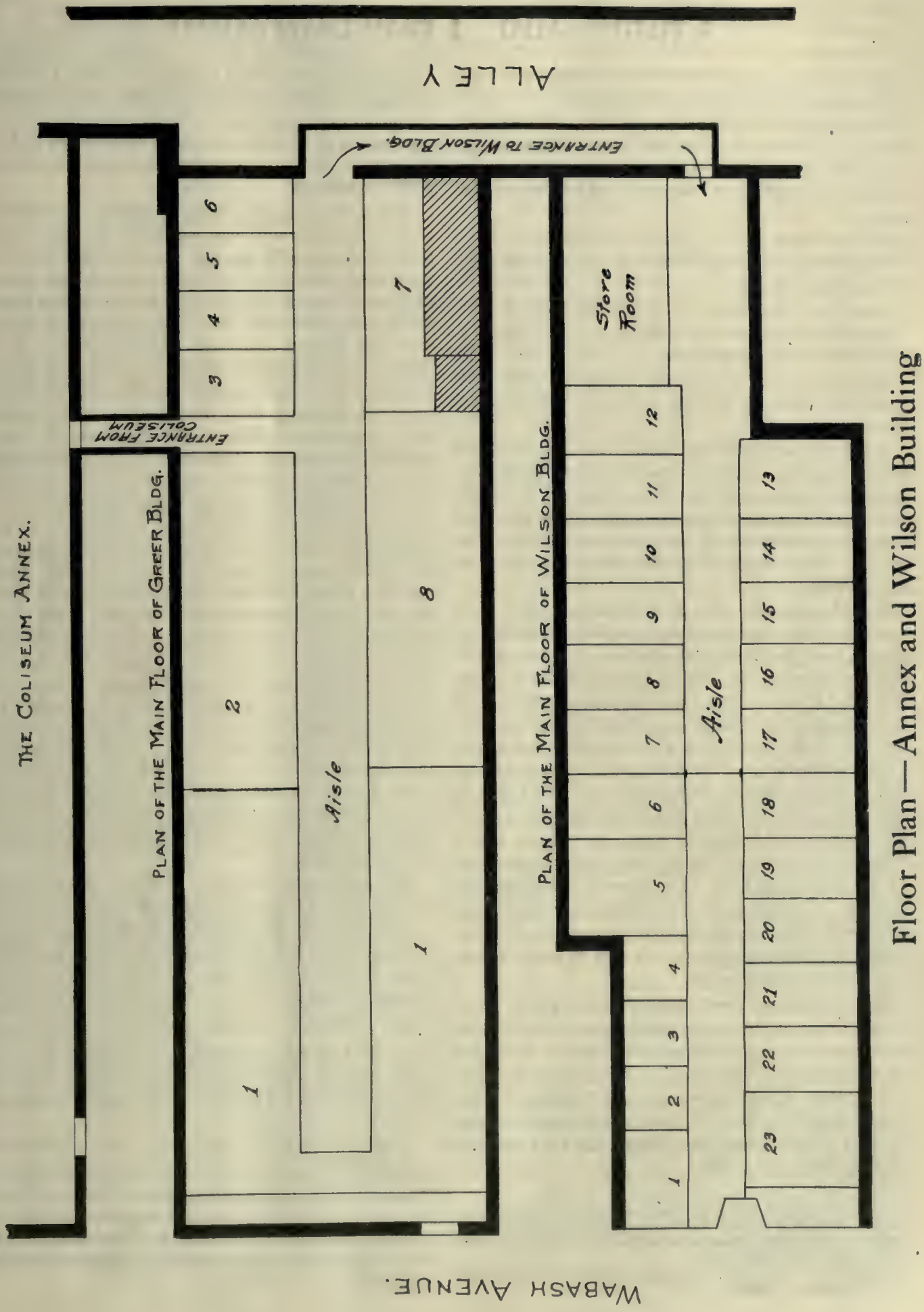
The prime object of the department's policy to eliminate grade crossings on federal aid roads is the saving of human lives. This policy probably will involve increased expense of construction in the case of some roads, but it is believed this is justified by the saving of life. During the three years ending with 1920, according to the best records available to the department, 3,636 lives were lost at grade crossings in the United States and 10,644 persons were injured.

NEW JERSEY SNOW REMOVAL PLANS

The New Jersey State Highway Commission has made elaborate plans for keeping the primary state roads clear of snow and the secondary routes open for travel during the winter. Contractors will operate on the former, using motor equipment, and the state's maintenance forces will take care of the less important routes.

The state roads in the primary system, so-called, comprise about 400 mi. They have been divided into 31 sections which have been assigned to various contractors. Motor trucks received by the state from the Government have been equipped with snowplows and distributed to these sections. Upon the approach of a severe snow storm, the Trenton office of the Weather Bureau will telephone to the various contractors. The contractors will then assemble their forces and begin work as soon as the snow is deep enough to warrant it. By this means it is hoped to keep the snow from accumulating on the roads.

The rest of the state roads, about 300 mi., will be kept open by the maintenance division of the State Highway Department with the equipment used in their regular maintenance work.



Floor Plan — Annex and Wilson Building

Traffic and Transportation*

Your Committee on Traffic and Transportation herewith respectfully submits its 1921 report.

Investigations conducted during 1921 influence the committee to strongly urge the general adoption, by municipal governments, of the recommendations embodied in its 1920 report relative to the following subjects:

Use of "dummy cops" at street intersections.

Installation of "rotary traffic" at street intersections wherever practicable.

Design and construction of long-radius curb corners.

Economic design of street widths on through thoroughfares in small towns and cities.

Utilization of pass highways for towns and cities located on important national, state, and country trunk highways.

Consideration of the installation of motor bus routes in municipalities, when an extension of the public passenger transportation system is required, in view of the resulting advantages of such installations from the standpoints of maintaining the maximum practicable traffic capacity of streets and of avoiding the use of car tracks in roadways.

Based on a careful analysis of public passenger transportation, your committee considers that it is highly desirable, from the standpoints of economic public service transportation and the efficient use of municipal streets by traffic, that the society should strongly condemn the development of "wild cat" so-called "jitney" service. Not only is the installation of such service undesirable from the standpoint of the overcrowding of streets with five-passenger public transportation vehicles but it is obviously unfair to public service corporations, operating under franchises, to be forced to compete with a "jitney" service which almost universally is operating on an uneconomic basis. The present overcrowding of some of the principal thoroughfares of the city of Detroit with hundreds of five-passenger "jitneys" furnishes a striking example of this type of public service transportation development.

Your committee recommends that a highway transport division should be installed in engineering or highway departments of municipalities having a population of over 100,000. The duties of this division would be to deal with all matters pertaining to traffic and transportation which affect the economic design and maintenance of streets and their efficient use by pedestrians and all classes of vehicles.

One of the important functions of such a division would be to make highway transport surveys as preliminary to the design and redesign of streets, the determination of efficient methods of maintenance and the formulation of recommendations pertaining to efficient traffic regulations.

A highway transport survey embodies all investigations in the field and office which are necessary to determine the probable amount, character and effects of the future traffic which will use a given highway during the lives of its several component parts. Such a survey for a given street may cover a consideration of all the following factors: First, all highway elements which affect economic highway transport; second, legislation relative to franchises and rates, weights, dimensions and speeds of passenger cars, trucks, tractors and trailers; third, state and urban traffic regulations; fourth, vehicular and population statistics; fifth, traffic censuses of motor and horse-drawn vehicles and cars operating on tracks; sixth, vehicular operation as affecting roadways and other parts of highways; seventh, present and future traffic and commercial transport developments in such fields as agricultural and dairy farming, mines, quarries, gravel and sand pits, oil fields, lumber tracts, fisheries, plants, factories, wholesale and retail stores, parks and parkways, summer and amusement resorts, and real estate improvements, which affect or will affect the traffic on the street under consideration; eighth, common carriers such as steam and electric railroads and waterway transportation companies and their relationship to street traffic; and ninth, the characteristics of the methods of highway transport such as street car rural, interurban and urban motor-bus operation, municipal haulage, long and short general rural haulage, rural motor express, intercity haulage, intercity express, and horse transport.

Men assigned to a highway transport division should be experienced highway engineers who have or are rapidly acquiring a knowledge of the following subjects: City planning; highway transport economics, legislation, surveys and methods; highway transport management, including delivery systems, scheduling and routing; traffic regulations; interrelationship of highway, railway and waterway transport; port, terminal and warehouse facilities; and the fundamentals of the mechanism and operation of automobiles, motor trucks, tractors and trailers.

Your committee has confined this report to two topics, namely, "jitney" transportation service and highway transport divisions of engineering or highway departments, as it is hoped that this concentration will encourage members of the Society to thoroughly discuss these important subjects during a meeting of the 1921 convention.

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*Report of the Committee on Traffic and Transportation of the American Society for Municipal Improvements, submitted at the 27th annual convention of the Society, Baltimore, Md., Oct. 25-28, 1921.

Committee: Arthur H. Blanchard, Chairman; Robert Hoffman, Charles O. Boyd.

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

Founded January, 1892

E. L. POWERS
Editor

11 WAVERLY PLACE
NEW YORK, N. Y.
Cable Address: Gudrodes, New York

Copy for advertisements must reach the New York office by noon on Tuesday of the week before date of issue if proofs are to be submitted.

Copy for classified and other advertisements where proofs are not required will be accepted until noon on Monday of the week of issue.

Articles by road builders are solicited. They should be short and, if possible, accompanied by photographs. Those accepted will be paid for at current rates.

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Vol. LXII January 11, 1922 Number 2

THE CONVENTION AT CHICAGO

The plans for the convention of the American Road Builders' Association, to be held in the Coliseum, Chicago, Ill., next week, are complete as this issue of GOOD ROADS goes to press. Great interest throughout the country is being manifested in the coming convention and it is expected that the record attendance at last year's convention held in the same city will be greatly surpassed. The number of exhibitors who have engaged space at the Good Roads Show, held in connection with the convention, is much larger than any previous show, and the amount of space which will be devoted to exhibits of road machinery and materials is double that of many previous shows. Not only has all the available exhibition space in the main floor of the Coliseum been taken, but the balcony and the Wilson and Greer Annexes have been leased to take care of the manufacturers desirous of exhibiting their products at the event of the year in road building circles.

A strong program of technical subjects has been prepared and many of the important problems confronting road builders will receive thorough consideration and discussion. Last year the daily technical sessions of the convention were shorter than usual because of the absence of extended discussions from the floor. The Program Committee, in selecting the subjects and speakers has endeavored to overcome this difficulty and it is expected that more extended discussions of the papers presented will result.

It is of particular significance that one of the sessions will be devoted to the discussion of highway research, at which session several prominent highway engineers who are making special investigations into matters of road design will present papers. The time was when a road was just built. And while we now know much more than we did a decade ago about building roads, there is much to be learned. A clear understanding of the factors which determine the life of a road can be arrived at only by scientific methods. Highway research is vital to the continued growth of the road building industry. Hundreds of millions of dollars are being expended on road construction in this country and it is expedient that our roads be built scientifically and economically. The road building industry can well profit by glancing at the part research has played in developing many of the other great industries in this country. The importance of highway research can not be over emphasized and it is hoped that it will receive increased attention at future conventions of the American Road Builders' Association.

The good roads movement has been gathering increased momentum each year, and each succeeding convention of the association is more important than the former. As more roads are improved and as traffic increases, many new problems and methods are brought before the American Road Builders' Association conventions for discussion. This interchange of ideas has had great influence in raising road building standards.

Since the passage of the Federal Aid Act the states have built up efficient engineering organizations, in many cases where none before existed, so that as a result every state in the Union is now prepared to go forward in road development. Congress, by making an appropriation last year to continue federal aid, in face of financial embarrassment of the Government, gave its approval of the present system of road development by the co-operation of the Federal Government with the various states, thereby indicating that highway construction will proceed without check. Many of the states have appropriated many millions of dollars for highway construction and as the financial situation becomes easier many states which hesitated to build roads will issue bonds for highway improvement. Thus the outlook for the coming year is bright, and undoubtedly at the close of 1922 the United States will find herself enriched with a considerable mileage of improved roads.

Many of the men who will help build these roads in 1922, road officials, contractors and engineers, will be in attendance at the convention in Chicago next week. There they will meet others engaged in highway work and be able to exchange ideas and experiences. The opportunity will also be afforded them to see the latest labor saving devices at the show, which will, it is said, be the largest collection of road machinery ever assembled in this country.

SURVEY OF ROAD WORK IN ILLINOIS

(continued from page 13)

tific investigations have not only made possible much better construction, but at a decided reduction in first cost. Auxiliary investigations, particularly with reference to the curing of concrete pavements, bid fair to result in better cured pavements and at lower costs than have heretofore applied.

Salient Features of the Illinois Road Law

The present road laws of Illinois are based upon the assumption that the revenue derived from motor license fees is sufficient not only to finance the maintenance of the trunk line roads of the state, but also to provide the funds required to prosecute a comprehensive construction program. The motor license fees in Illinois average about $12 per motor vehicle. In 1921 the revenue derived from this source approximated seven million dollars. It may thus be seen that the assumption above indicated is not out of line.

The bonds to be issued by the state will be retired from future motor license fee collections; but it is believed that this fund will be sufficiently large to do this, and also to provide amply for the maintenance of the state highways, and meet any federal appropriations that may be made available.

Recent legislation provided that the Department of Public Works and Buildings may take over for maintenance, in addition to the completed trunk line roads, (at its option) all roads of the trunk line system previous to construction.

The Illinois motor vehicle law covers in a comprehensive way regulations for the control of motor truck traffic. It is believed that the most important feature of this law is embodied in the provision that axle loads may not exceed 16.000 lb. which in effect limits the load imposed by any wheel of a truck to four tons. The motor vehicle law also gives to the Department of Public Works and Buildings authority to appoint traffic patrol officers in order that load limitations may be effectively enforced. This department of the Division's activities is now being organized; and it is expected that in 1922 the overloading of trucks, so destructive to the pavements, will be prevented.

In general, legislation during the past ten years has been gradually developing toward a unified state organization having control of all highway work. All highway bridges, wherever constructed, must be built in accordance with the regulations of the Department of Public Works and Buildings. All units of road work, costing in excess of $200 must be carried out under the direction of the various county superintendents of highways who, in turn, are deputies of the chief highway engineer and subject to the regulations of the Department of Public Works and Buildings. This centralization of the general control of all highway work is resulting in a gradual improvement in the administration of the work all down the line to the township highway officials.

The 1922 program of the Department of Public Works and Buildings calls for the construction of approximately 1,100 mi. of pavement; more than 300 mi. of heavy grading; and 200 large bridges. It is expected that within the next two months lettings will be held and awards made for that part of the program which is not already under contract.

"SONGS OF THE ENGINEER"

"The engineer is very generally thought of as a most prosaic individual, entirely lacking in romance or imagination," according to a writer in a recent issue of the *Professional Engineer*, the organ of the American Association of Engineers. "As a matter of fact," however, he continues, "the average engineer is so busy living a life of unsung romance, and the most prosaic of his work is so filled with imagination and creative thought, that he has hardly had time to get a proper perspective of himself—to get off at a distance and, looking from one mountain peak of achievement, to see across the valley how the opposite mountain has been molded for the advancement of humanity by the efforts of the engineer."

Elsewhere in the same issue of the *Professional Engineer* are printed several songs and verses about engineers and their work. One of them, credited to C. Wiles Hallock and dealing with the branch of engineering followed by readers of GOOD ROADS, is presented below:

The Men Who Make the Roads

O, brothers of the open road,
Be mindful, in your motors,
Of this, our common gift, bestowed
By less enleisured voters.
Be mindful how these thorofares,
Were made to serve all comers—
The meek and humble millionaires,
The plutocratic plumbers.

O, Brothers, when you motor out,
In double fours or flivvers,
To lamp the landscape round about
And agitate your livers,
The while your gas-consumer flies,
O'er beaten trails and by-ways—
O, breathe a prayer and bless the guys
That built the bloomin' highways.

Be mindful of their lowly lot;
They rarely ride as you do.
You drive nice cars, but they do not;
At least, a very few do.
And life would be a dreary hike
If it were not for fellows like
The ginks that give us highways.

The Connecticut State Highway Commissioner and the Motor Vehicle Commissioner have made a joint ruling permitting the registration of a commercial motor vehicle for more than its rated capacity upon obtaining from the engineering department of the manufacturer of said vehicle a certificate to the effect that it can be operated safely at all times and under all conditions when so over-loaded. The ruling does not affect the previous ruling of the State Highway Department that gross loads must be limited to 25,000 lbs., total, or 800 lb. per inch of tire width.

The American Road Builder's Association and Its Meeting at Chicago

An Organization that in Two Decades of its Existence Has Played a Leading Part in the Great Work of Building Up the Nation's Highway Transportation. Facilities—Previous Conventions and Road Shows—Program of the Nineteenth Annual Convention.

Twenty years ago road building was little more than a hope. A number of states had adopted the principle of state aid, establishing highway departments and making small appropriations to aid the counties and the towns in the improvement of their roads. The departments had comparatively little power, however, and the initiating of work lay almost entirely with the local communities. A certain measure of control over what should be undertaken was vested in the state officials, but it amounted to little more than the veto power. The work once begun, the state exercised at least a nominal supervision, but even then the departments—measured by present standards—were weak.

Among those who had been chosen to carry on the work of highway improvement in the pioneer states of the East were several men of vision. With others who saw the making of the nation's roads as one of the great works of the future, these men gathered in New York City in 1902 and organized an association that they called the American Road Makers. One of their first acts was to send out a call to the country's road builders —then a small, but earnest group—to assemble at a convention at Detroit, Mich., on Feb. 13 and 14, 1903. The meeting was held and was so much of a success that the leaders of the movement decided to hold annual meetings in the future.

This, in brief, is the story of the founding of the American Road Builders' Association—an organization that in twenty years of service in the cause of better roads has witnessed the spread of the state aid principle to every state in the Union; has seen federal aid materialize, and has led in the efforts that have expanded the organized and co-ordinated road program of the country from a matter of a few million dollars to one of more than half a billion. During its comparatively short life, the character of traffic has almost entirely changed and has increased in volume to a point beyond the most sanguine expectations of even the most farseeing of its

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Northeastern District

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Central District

W. W. CROSBY
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Western District

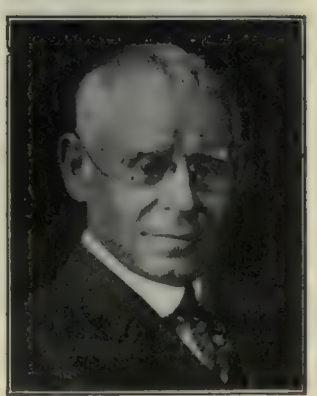
E. L. POWERS
Secretary

EXECUTIVE OFFICERS

OF THE

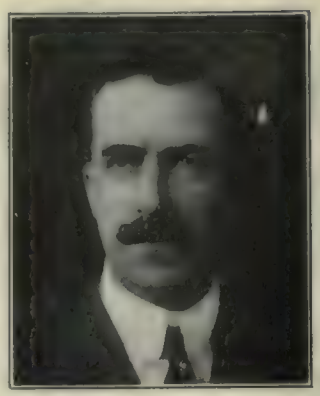
American Road Builders' Association

1921-1922



J. H. MACDONALD
Treasurer

founders. Since it was organized road building has evolved from a hit-or-miss, rule of thumb process to a science and art ranking high among the various branches of engineering, with a literature of its own and a practice that has kept pace with the rapidly changing conditions it has had to meet. In the two decades of its efforts in the forefront of the struggle for highway betterment, the equipment of the road builder has been developed from the dump cart, road roller and pick and shovel, to the varied machines and tools that will fill to overflowing the Coliseum at Chicago next week. In the same way, the materials that the road builder uses have been increased in number and improved in quality. The business of road building too, has undergone a transformation. No longer is a road contractor a workman who has accumulated enough ready money to buy or hire a few horses and end-dump carts and to meet a few weeks' payroll. The modern contractor uses extensive and costly plant and takes jobs at six figures that in the old days would represent a state's annual program.



A. W. DEAN

H. E. BREED

M. J. FAHERTY

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M. F. BRAMLEY

F. E. EVERETT

F. E. ROGERS

LT. COL. W. D. UHLER

I. W. PATTERSON

WM. R. SMITH

DIRECTORS OF THE AMERICAN ROAD BUILDERS' ASSOCIATION

And in all of this advance the American Road Builders' Association has played its part. It has numbered in its membership the leaders in every branch of the work to which it is dedicated—officials, engineers, contractors, educators and publicists. It has exerted its influence on the side of wise legislation, sound financing, able administration, and efficiency and economy in construction and maintenance. It has constantly and consistently urged the adoption of engineering principles that

T. E. ELLIS

in the experience of its members have been found good. It has emphasized the need of traffic study and the devoting of more attention to the economic phase of road improvement. It has worked for the recognition of highway engineers and for a better understanding and more genuine co-operation between engineers and contractors. And by means of the exhibitions that have been such important parts of its meetings for the past twelve years, it has performed an incaluable service to road builders in affording them unparalleled opportunities to keep abreast of the development of road building machinery and materials.

The chief agency through which the association has worked has been its annual convention. Its first meeting, in 1903, having demonstrated the value of such gatherings, the second was held at Hartford, Conn., on Feb. 10 and 11, 1904. That meeting was a repetition of the previous success, but on a larger scale. The attend-

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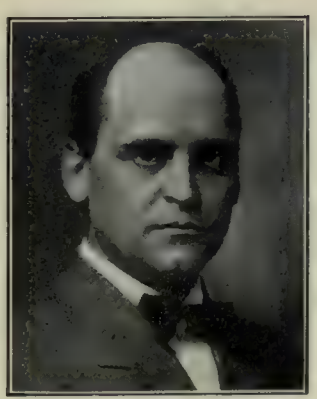
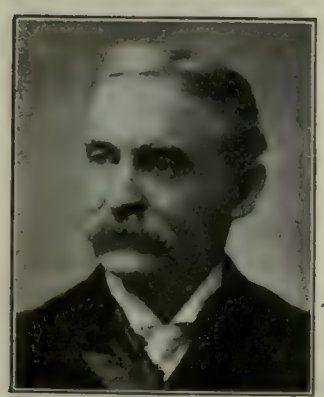


A. B. FLETCHER

S. E. BRADT

DIRECTORS OF THE AMERICAN ROAD BUILDERS' ASSOCIATION



GEO. W. TILLSON

ance was over 1,000. The exhibition feature proped so valuable that another was held the next year and then became a permanent adjunct of the annual convention. It was omitted only once thereafter—in 1915 when the American Road Builders' Association held a joint meting with the American Highway Association and a number of local organizations at the Panama-Pacific Exposition.

The seventh annual convention was held at Indianapolis, Ind., on Dec. 6, 7, 8 and 9, 1910, with over 1,400 members in attendance and 45 exhibitors displaying their goods. The eight annual convention and the third exhibition of machinery, equipment and materials was held at Rochester, N. Y., on Nov. 14, 15, 16 and 17, 1911, with ten more exhibitors than the previous exhibition and with a slightly greater attendance of members. At this meeting the method of proceedure in conducting the meetings was altered, each session being

devoted to the consideration of some particular topic which was introduced by a formal paper. This introductory paper was followed by two formal discussions and by a general discussion open to the convention.

In 1914 the association met at Chicago, Ill., on Dec. 14 to 18, with the attendance over 3,500 members and the exhibitors numbering 116. In 1915, as mentioned above, the American Road Builders' Association joined with the American Highway Association and several local road organizations in holding a joint convention at Oakland, Cal., during the Panama-Pacific International Exposition. In 1918 the fifteenth annual convention was held in St. Louis, Mo., on Feb. 4, 5, 6 and 7. In 1920 the sixteenth annual convention was held in New York City on Feb. 25, 26, 27 and 28. At the 1919 and 1920 conventions the elaborate displays of heavy machinery were omitted because of war conditions and portable exhibits were held in the hotels. In 1920 the seventeenth annual convention was held in Louisville, Ky. Last year the eighteenth annual convention was held in the Coliseum, Chicago, Ill., with an attendance and variety of exhibits which broke all former records.

In the language of its constitution, the objects of the American Road Builder's Association are "to acquire and disseminate information concerning highway construction and maintenance in the states and cities of the Union and in the provinces and cities of Canada; to stimulate iterest in the subject, and to promote educational, legislative and other measures tending to their accomplishment." The annual meetings form a clearing house for ideas and experiences of leaders in the road building field. Papers are prepared and read, and extended discussions upon the subjects follow in which all in attendance may participate. In this way all the members attending the session profit by the thoughts and experiences of men from all parts of the country engaged in road building. These papers and discussions are printed in full annually in the proceedings of the association and copies are distributed free to the members.

In 1918 a constitutional amendment was adopted dividing the membership of the organization into five classes, as follows: Active, life, sustaining, contributing and honorary. Active members are "persons who are actively engaged in laying out or supervising the construction and maintenance of highways and streets and those interested in highway development." The annual dues for active members are $3.00. Life members are active members making a payment of $100 upon election to membership. Sustaining members are companies or organizations contributing $200 yearly, and contributing members are companies or organizations contributing $50 yearly. Honorary members are "those who have performed distinguished service in the cause of highway extension and improvement" and are nominated by the board and elected by the association. Active members are elected by the executive committee upon the recommendation of an active member. Only active and life members may vote or hold office.

The present officials of the association are as follows:

President, H. L. Bowlby, Chief, War Materials Division, U. S. Bureau of Public Roads, Washington, D. C.; Vice-President, Northeastern District, Charles J. Bennett, State Highway Commissioner of Connecticut; Vice-President, Southern District, Frank Page, Chairman, North Carolina State Highway Commission; Vice-President, Central District, A. R. Hirst, State Highway Engineer of Wisconsin; Vice-President, Western District, W. W. Crosby, National Park Service, Estes Park, Colo.; Secretary, E. L. Powers, Editor, "Good Roads"; Treasurer, James H. MacDonald, Former State Highway Commissioner of Connecticut.

Past Presidents: A. W. Dean, Chief Engineer, Division of Highways, Massachusetts Department of Public Works; H. E. Breed, Consulting Highway Engineer, New York, N. Y.; A. H. Blanchard, Professor of Highway Engineering and Highway Transport, University of Michigan, Ann Arbor, Mich.; Geo. P. Coleman, State Highway Commissioner of Virginia; M. J. Faherty, President, Board of Local Improvements, Chicago, Ill.

Directors: H. K. Bishop, General Inspector, U. S. Bureau of Public Roads, Washington, D. C.; M. F. Bramley, President, Trinidad Paving Co., Cleveland, O.; F. E. Everett, State Highway Commissioner of New Hampshire; Samuel Hill, Honorary Life President of the Washington State Good Roads Association; J. Frank Smith, Manager, Good Roads Association of Greater Kansas City, Kansas City, Mo.; C. M. Upham, Chief Engineer, Delaware State Highway Department; T. J. Wasser, State Highway Engineer of New Jersey; R. A. Meeker, Right-of-Way Engineer, New Jersey State Highway Department; F. F. Rogers, State Highway Commissioner of Michigan; Lt. Col. W. D. Uhler, Chief Engnieer, Pennsylvania State Highway Department; Irving W. Patterson, Chief Engineer, Rhode Island State Board of Public Roads; William R. Smith, President, Lane Construction Corp., Meriden, Conn.; John Swan, Fort Pitt Construction Co., Pittsburgh, Pa.; J. H. Cranford, President, The Cranford Paving Co., Washington, D. C.; W. G. Sucro, County Roads Engineer, Baltimore County, Maryland; W. A. McLean, Deputy Minister of Highways, Province of Ontario, Canada; A. B. Fletcher, State Highway Engineer of California. S. E. Bradt, Former State Superintendent of Highways of Illinois, DeKalk, Ill.; Fred E. Ellis, Manager, Essex Trap Rock & Construction Co., Peabody, Mass.; Fred W. Sarr, First Deputy State Highway Commissioner of New York; George W. Tillson, Consulting Engineer, La Grange, Ill.

The coming convention will be held on Jan. 16, 17, 18, 19 and 20 at the Coliseum, Chicago, Ill. A strong program for the technical sessions has been prepared, which together with the fact that the number and variety of exhibits of road building machinery and materials will be larger than at any previous convention,

makes it appear at this writing that the attendance will be much greater than ever before.

PROGRAM

MONDAY, JANUARY 16

The Thirteenth National Good Roads Show will be opened to the public at 8 p. m., Monday, January 16. The show will be held in the Coliseum.

TUESDAY, JANUARY 17, 1922.

Coliseum, 10 a. m.

First Session

Meeting called to order by the President of the American Road Builders' Association, H. L. Bowlby.
Invocation
Announcement of Convention Committees
Address of Welcome on Behalf of the City of Chicago, by Hon. William Hale Thompson, Mayor of Chicago.
Response on Behalf of the American Road Builders' Association, by Frank Terrace, President, Washington State Good Roads Association.

Second Session.

Coliseum, 2 p. m.

J. H. Mullen, Chief Engineer, Minnesota State Highway Department, presiding.

"Bituminous Foundations," by Hugh W. Skidmore, Chicago Paving Laboratory, Chicago.

"Utilization of Local Materials for Mineral Aggregate," by W. A. Welch, Chief Engineer, Palisades Interstate Park Commission, New York.

"Asphalt Specifications," by Al. M. Law, Chief Chemist, New Orleans Refining Company, New Orleans, La.

"Specifications for Mineral Aggregates," by Roy M. Green, Western Laboratories, Lincoln, Nebraska.

"Controversial Construction Requirements in Specifications," by Bruce Aldrich, Kilmer & Barber, Toronto, Canada.

Smoker, 8 p. m.

A smoker will be held at a hotel to be announced. All delegates are invited as the guests of the Association. Appropriate entertainment will be provided.

Third Session

Coliseum, 10 a. m.

C. M. Upham, Chief Engineer, North Carolina State Highway Department, presiding.

WEDNESDAY, JANUARY 18

"The Highway Outlook," by Thomas H. MacDonald, Chief, U. S. Bureau of Public Roads, Washington, D. C.

"Development of Small Stream Valleys Into Traffic Routes," by Jay Downer, Chief Engineer, Bronx Parkway Commission, New York.

"Cooperation of All Parties Interested in the Construction of a Modern Road," by William Ord, Manager, Paving Dept., The Lakewood Engineering Company, Cleveland, Ohio.

"Uniform Legislation as Affecting Highway Traffic and Highway Transport," by D. C. Fenner, Manager, Public Works Department, International Motor Company, New York.

Fourth Session

Coliseum, 2 p. m.

M. O. Eldridge, Chairman, Roads Board, American Automobile Association, presiding.

"Highway Finance," by Arthur H. Blanchard, Professor of Highway Engineering and Highway Transport, University of Michigan.

"The Minnesota Experience in Highway Financing," by C. M. Babcock, Commissioner of Highways, Minnesota State Highway Department.

"The Proposed Wisconsin Plan of Highway Finance," by A. R. Hirst, Chief Highway Engineer, Wisconsin Highway Commission.

"The Business End of a State Highway," by C. M. Upham, Chief Engineer, North Carolina State Highway Department.

"A Simple Graphic Method of Proportioning Sands for Sheet Asphalt Mixtures," by Prevost Hubbard, Chemical Engineer, The Asphalt Association, New York City.

"The Use of Brick for Street and Road Surfaces," by W. W. Horner, Chief Engineer, Sewers and Paving, St. Louis, Missouri.

President's Dinner

Congress Hotel, 6:30 p. m.

There will be no formal entertainment of the delegates. The evening is left open for special parties.

President's dinner to the Past Presidents and Directors of the Association at the Congress Hotel, 6:30 p. m.

THURSDAY, JANUARY 19.

Fifth Session.

Chicago Coliseum, 10 a. m.

A. R. Hirst, Wisconsin State Highway Engineer, presiding.

"The Selection of the Mineral Aggregate for a Portland Cement Concrete Road," by C. Gray, Chief Engineer, State Highway Department of Indiana.

"Design of Concrete Roads for Heavy Traffic," by J. W. Hunter, First Deputy Highway Commissioner, Pennsylvania State Highway Department.

"Inspection and Control of Materials for Concrete Roads," by R. W. Crum, State Testing Engineer, Iowa Highway Commission.

"Importance of Surface Finish and Methods of Control," by H. E. Breed, Consulting Engineer, New York City.

"Single Track Concrete Roads for the Average County," by P. C. McArdle, County Highway Superintendent, Vermilion County, Illinois.

"Pavement Widths for Highways Serving Large Cities," by H. E. Surman, Engineer of Design, Illinois State Highway Department.

Sixth Session

Coliseum, 2 p. m.

Arthur H. Blanchard, Professor of Highway Engineering and Highway Transport, University of Michigan, presiding.

"Truck Overloading; Its Relations to Road Construction and Maintenance," by J. G. McKay, Ph.D., Professor of Economics, University of Wisconsin.

"The Illinois Experimental Road," by Clifford Older, Chief Highway Engineer, Department of Public Works, Illinois.

"Highway Research," by W. K. Hatt, Prrofessor of Engineering, Purdue University; Director of Research, National Research Council.

"Highway Researches and What the Results Indicate," by A. T. Goldbeck, Chief, Division of Tests, U. S. Bureau of Public Roads, Washington, D. C.

Annual Dinner

Congress Hotel, 6:30 p. m.

In addition to the dinner, there will be provided an excellent entertainment.

FRIDAY, JANUARY 20

Seventh Session

Coliseum, 10 p. m.

H. G. Shirley, County Engineer, Baltimore County, Maryland, presiding

"Construction and Maintenance of Earth Roads," by George E. Johnson, Secretary of Public Works, Lincoln, Neb.

"A Systematic Study of Gravels for Road Purposes," by Wallace F. Purrington, Chemist and Testing Engineer, Highway Department of New Hampshire.

"Cost Keeping on Highway Construction," by A. R. Losh, Assistant Chief of Construction, U. S. Bureau of Public Roads, Washington, D. C.

"The Highway Contractor's Problems," by H. H. Wilson, Winston and Company, New York, N. Y.

Eighth Session

Coliseum, 2 p. m.

H. L. Bowlby, President, the A. R. B. A., presiding.
Report of Resolutions Committee
Election of Nominating Committee
Unfinished Business
Adjournment

BRIDGE IN FLORIDA COLLAPSES

A concrete bridge under construction over Lake Worth, between Palm Beach and West Palm Beach, Fla., recently collapsed. The bridge had just been completed and was to be opened to traffic in a few days.

GOVERNMENT SEES SOLUTION OF HEAVY MOTOR TRUCK PROBLEM

Annual Report of the Bureau of Public Roads Taxes Up Vexed Problem of Adjusting Loads and Roads

The proper regulation of unusually large motor trucks because of their wear and tear on the country's highways, or of restricting their use to certain roads designed to accommodate them, is suggested for consideration in the annual report of the Bureau of Public Roads of the United States Department of Agriculture. It is asserted that the problem of the heavy motor truck is one of prime importance, that it becomes more urgent each year, and that, while not to be solved hastily, it will have to be met squarely and disposed of ultimately.

"The reduced unit cost of operation which follows from the transportation of commodities in greater bulk tends to promote the development and use of vehicles of the largest capacity," according to the report. "It is desirable to gain this advantage, if it is actually an advantage, but it is this point which is seriously in doubt. The doubt arises from the fact that the roads which are adequate ffor traffic automobiles and light trucks are entirely unable to support the weight of the heavier trucks, and to build roads which will carry the heavy vehicles will greatly increase the cost of construction.

"Whether the operation of the heavier vehicles shall be restricted to a class of roads especially designed to accommodate them, or whether all roads shall be strengthened to provide for unrestricted use, or whether the third alternate shall be adopted and the operation of the heavier trucks prohibited, will depend upon the relation which is found to exist between reduced operating cost and increased cost of construction.

"The situation presents an economic problem of the first importance which is not to be hastily solved, but which must nevertheless be met and disposed of. To do so demands a careful weighing of the effects of the several possible solutions with a view to the selection of that one which, in the long run, will serve best to accomplish the one desirable end—the improvement of our means of transportation.

"The prime importance of an accurate knowledge of the weights of the vehicles which are to use the roads constructed is well illustrated by the experience of one of the states in which the Bureau of Public Roads made an extensive investigation during the past year.

"Ten years ago this state set out upon the construction of a system of roads. The roads were designed and built to meet all the reasonable demands of the traffic which then could be foreseen. In the brief time which has elapsed roads have been constructed which penetrate to all parts of the state, some of which, however, have been seriously damaged by heavy motor vehicles, the use of which could not have been foreseen when the roads were constructed.

"Our investigation reveals that in this case the return from the roads in the reduction in the cost of transportation and in the development of the territory they traverse has undoubtedly compensated the loss resulting from their destruction; but it is not by any means certain that the outcome will be so fortunate under other conditions.

"For the security of the enormous investment which is being made by the states and Federal Government, it is imperative that this question of the duty which the roads will be called upon to render in the future shall be definitely determined. A clearer conception of the relative economy of heavy and light vehicles can be gained by careful study."

Another problem presenting itself for solution—and under investigation—is the variance of the classes of traffic to be served in different localities. Pointing out that the demand for good roads comes from all classes of highway users, the bureau asserts that:

"The demand of the farmer is for roads from shipping points and agricultural centers to the surrounding areas—farm-to-market roads. The manufacturer and city merchant ask principally for roads which will facilitate the transportation of raw materials and manufactured commodities which flow to and from the cities. The tourist, and that large section of our urban population whose direct interest in the rural roads is due to the opportunities for pleasurable recreation which they afford, are particularly concerned in the development of a system of smooth, hard-surfaced roads connecting the cities and points of natural interest. Thus, from the several classes the demand is for roads to meet their particular requirements, while all unite in an appreciation of the need for development of a system of roads which shall serve as a complete supplement to the railroads in the event of war.

"All these are proper demands, which must be accommodated as rapidly as the resources and means of construction will permit. Fortunately, the more important requirements of each group may be met by the improvements of a relatively small part of our mileage of public roads."

Five Million Dollars for New Connecticut State Highways was the program outlined by Motor Vehicle Commissioner Robert B. Stoeckel, of Hartford, Ct., recently, to care for increased automobile traffic, which, he said, was crowding the present state roads. He said he believed that the highways would become more congested with the betterment of industrial conditions. "It will result in increased sale of automobiles and make new highway construction imperative," he said.

The Agricultural Commission of the American Bankers' Association at a recent convention in California reported that it was squarely behind the measure that provides for the construction of transcontinental highways, because of the value of good roads to the farmer and the resultant upbuilding of the state and the nation. The report was submitted by W. C. Gordon, President of the Farmers' Saving Bank, of Marshall, Mo.

Subgrade Drainage Tests Yield Interesting Preliminary Data*

BY IRA B. MULLIS†

The subgrade drainage experiments which have been in progress at Arlington, Va., experiment station of the Bureau of Public Roads since the fall of 1920 are yielding some interesting preliminary data. The more important indications noted to date are that with deep drainage ditches unobstructed, the upper layers of the soil contain more moisture than the underlying soil, a condition which is reversed by flooding the ditches; that treatment of the subgrade with water-gas tar or the construction of cut-off walls along the edges of the surface have a marked effect in reducing the moisture content of the upper layers of the soil; that the amount of moisture near the surface is increased by alternate freezing and thawing, and that marked movement of the overlying slab results from temperature changes as well as from the changes in moisture content of the subgrade.

Description of the Experiment

For the purposes of the experiment 10 concrete slabs, each 14 ft. square, have been laid and surrounded by ditches as shown in the illustration on page 33 of this issue. Each section was constructed entirely in cut and cutting below grade at any point was carefully avoided, so that the natural earth conditions would not be changed by any filling. The Susquehanna clay soil which composed the subgrade was not rolled, but at the time the pavements were laid it was unusually dry and compact.

As shown by the cross-sections on this page, the drainage of section 1 is accomplished only by the slope of the earth shoulders and by longitudinal drains. In section 2, an attempt has been made to prevent any water from entering the subgrade by horizontal capillarity from the shoulders, and to drain any excess water through the tile and gravel drain under the edge of the pavement.

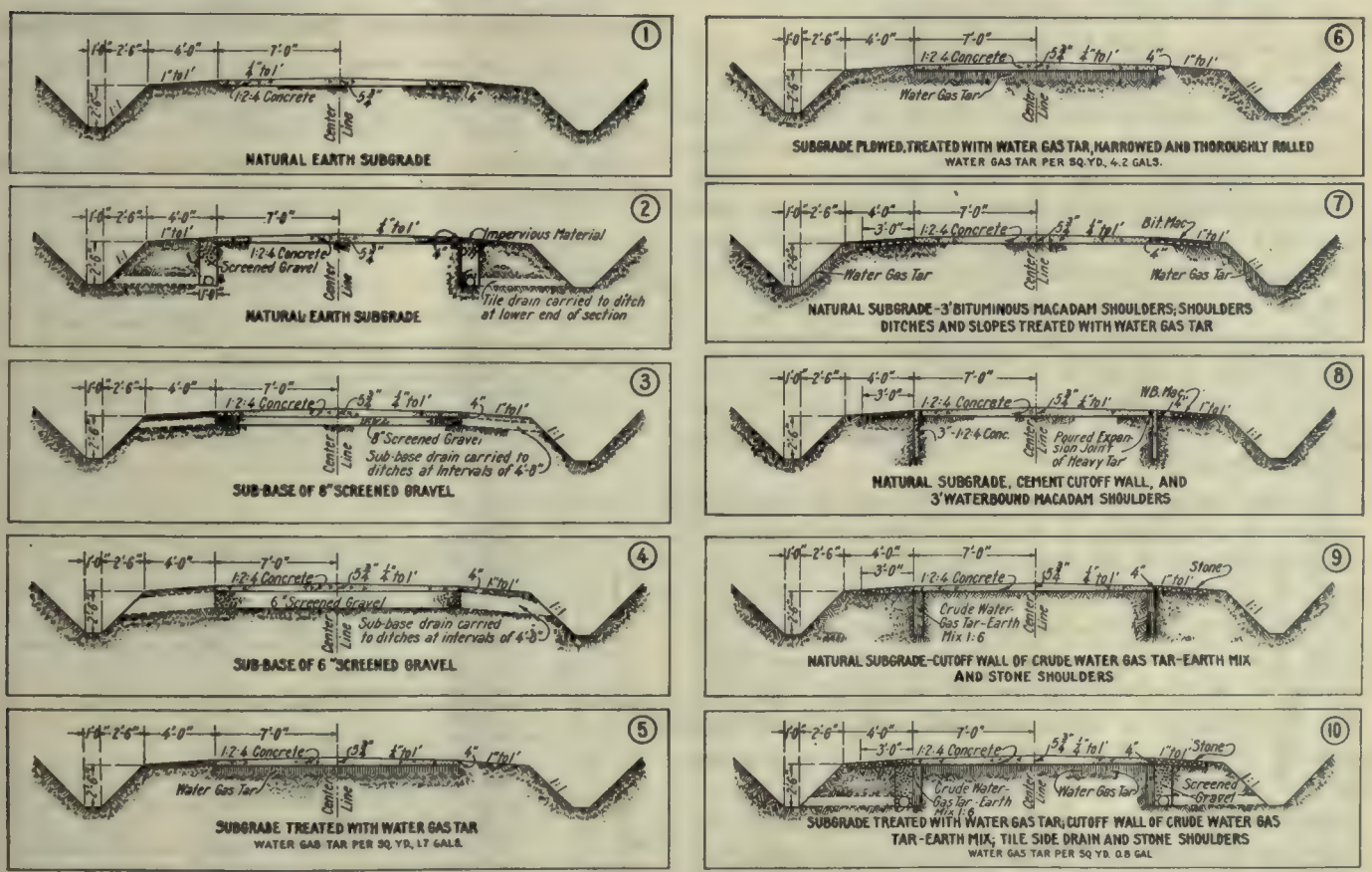
In sections 3 and 4, gravel is used for the purpose of distributing any loads on the pavement as well as for draining and aerating the subgrade.

Crude water-gas tar is used in sections 5 and 6 to waterproof the subgrade and thereby cause it to render greater support to the pavement.

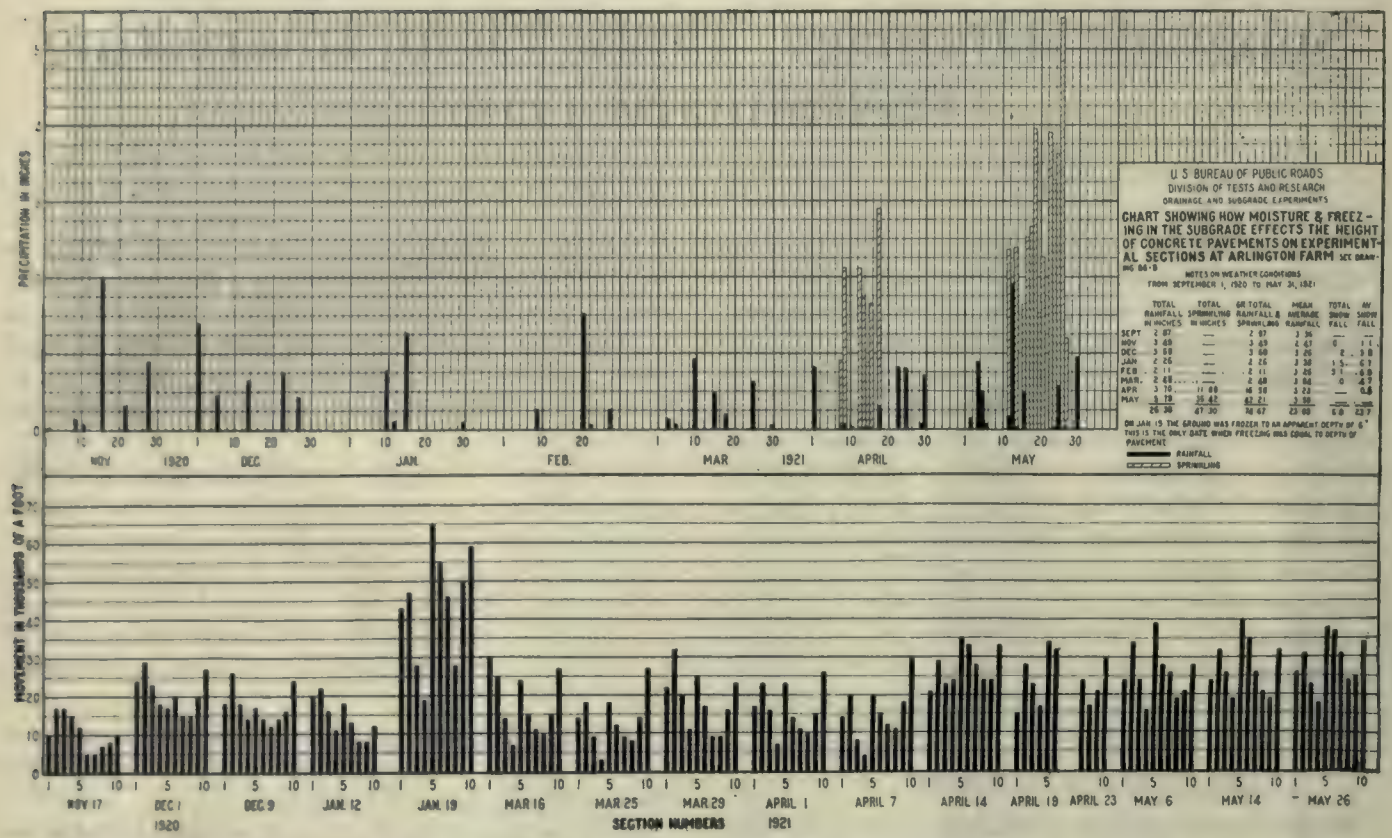
Waterproofing has been resorted to on section 7, the attempt being made to waterproof shoulders from rain-

* From "Public Roads," the official publication of the Bureau of Public Roads, U. S. Department of Agriculture.

† Assistant Testing Engineer, Bureau of Public Roads.



CROSS-SECTIONS SHOWING SLABS AND VARIOUS SUBGRADE TREATMENTS IN DRAINAGE EXPERIMENTS



SHOWING HOW SUBGRADE MOISTURE AND FREEZING EFFECT THE HEIGHT OF CONCRETE PAVEMENTS

fall and the insides of the ditches against horizontal capillarity.

Horizontal capillarity is attacked in sections 8, 9, and 10 by the various methods indicated.

The square plates shown in the illustration on page — are water-tight caps fitted over openings in the pavements which extend entirely through the slabs for the purpose of making examinations of the subgrade, taking soil samples for moisture determinations, etc. The sheet-metal-encased wells, shown in the shoulders, were provided to show the elevation of the ground water. The casings of these wells are perforated below the surface of the ground to admit the water.

The lateral ditches may be drained or flooded for the purpose of studying the effect upon the subgrade. Upon the completion of the studies involving the use of ditches, they will be filled with earth and the experiments continued.

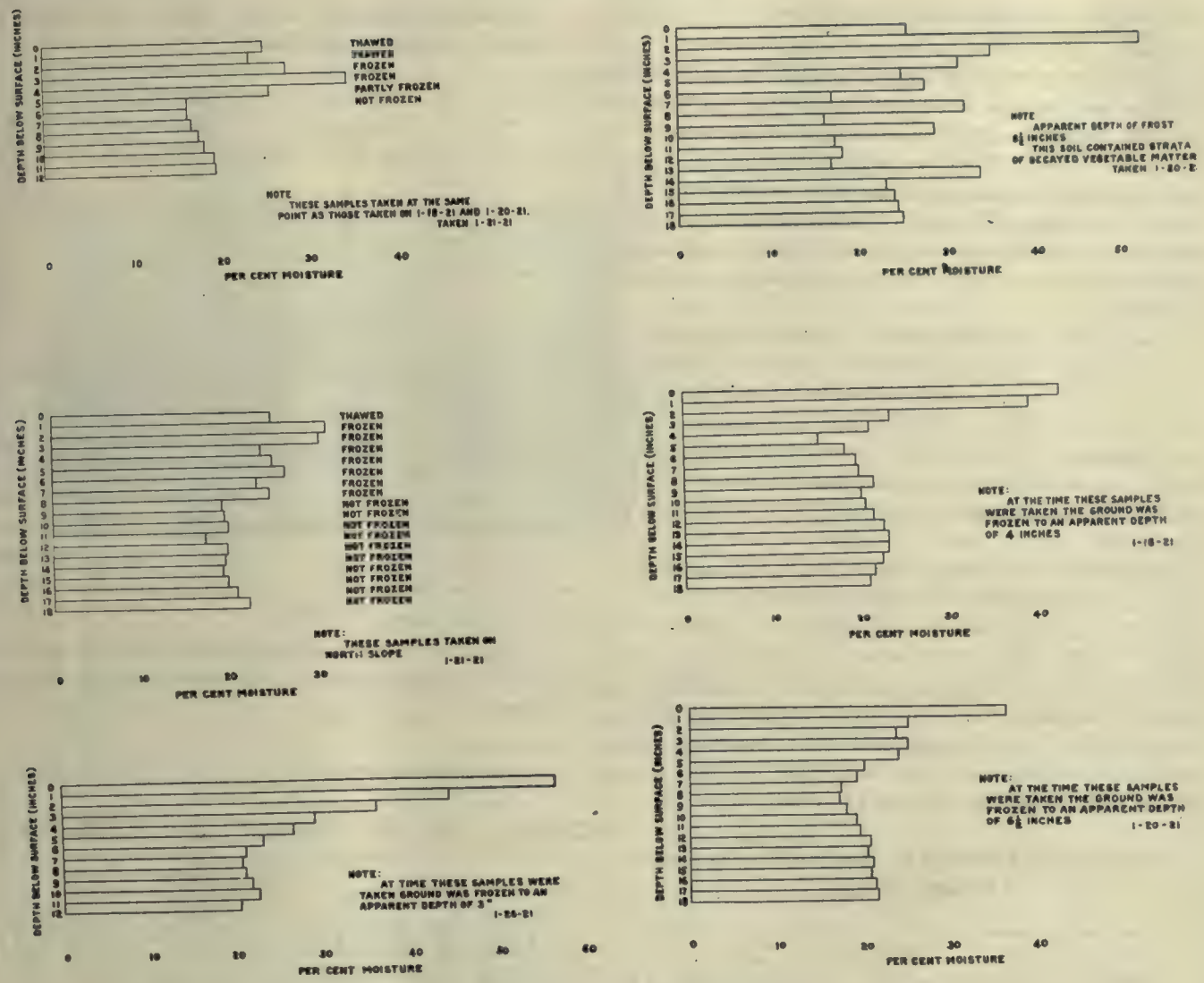
In addition to taking samples of the soil for moisture content determinations, a careful record of rainfall and daily temperatures has been kept throughout the test; and, to follow the movements of the slabs resulting from moisture and temperature changes, precise levels have been taken from time to time on brass plugs embedded in the four corners and center of each slab. The bench mark to which the levels are referred consists of a truncated cone of monel metal in the upper end of a 1¼-in. galvanized iron pipe rising from a concrete base about 4 ft. under ground. To protect the bench mark from the effects of temperature and frost the pipe was inclosed in a cylindrical casing closed at the top by means of a screw cap, and resting at the bottom on the concrete base, the lower end being waterproofed with 4 in. of heavy asphalt which securely seals the joint with the concrete base.

Observations of Moisture Concrete and Slab Movement

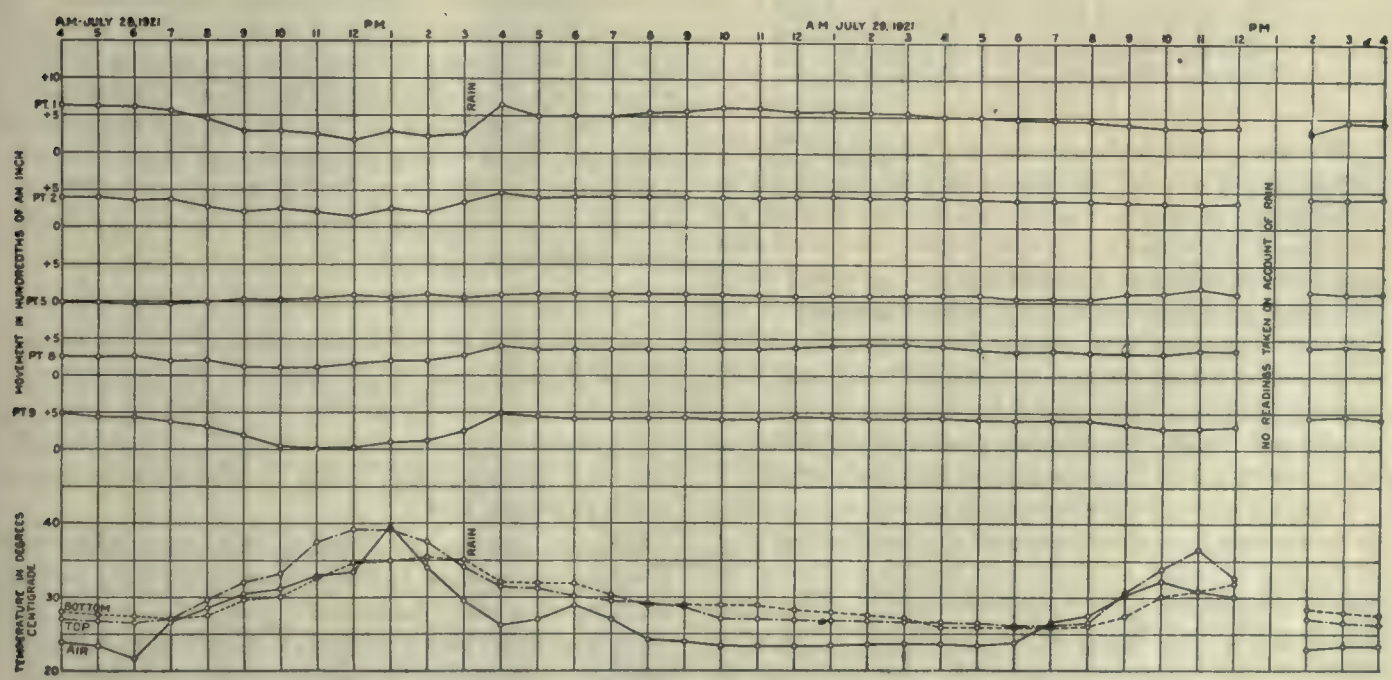
Moisture samples were taken from the subgrades throughout the fall and winter of 1920, but no great amount of water was observed until Jan. 19 when, immediately after a 6-in. freeze, the following observations were made:

Section No.	Well No.[1]	Moisture condition.
1	1	Frosty, free water pressed out.
	2	Ice crystals in auger holes. These holes seem to make this well rather dry in appearance, still frozen
1	7	Free water one-half inch deep.
	(2)	Frozen and rather dry.
	(3)	Wet, slaked, and contains free water.
2	1	Upper one-fourth inch very moist, still partly frozen.
	3	Ice crystals and slightly upheaved.
	5	Very wet, clay slaked.
3	1	Dry.
	3	Moist, but no free water.
	5	Do.
4	1	Frosty on top.
	3	Drier than perhaps any section in experiments.
5	1	Frost has upheaved surface. No water can be pressed out with thumb.
	3	Ice crystals under subgrade.
	7	Subgrade frosty and heaved.
6	1	Pressure of thumb will squeeze out water.
	3	Clay under surface of subgrade moist. Top of soil not as bad as well 7 of this section. This is probably due to borings which offer greater opportunity for drying out.
	5	Subsoil rather moist, but not wet.
	7	Clay moist and disintegrated by frost.
7	1	Clay slaked, no free water above surface.
	3	Ice crystals.
	7	Free water one-fourth inch deep.
8	1	Ice crystals showing
	3	Somewhat frozen
	4	Frosty with ice crystals showing.
9	1	1 inch of water standing on top of subgrade.
	3	Partly thawed, and clay slaked.
	7	1 inch of free water on top of subgrade.
10	1	Clay just under coating of water-gas tar entirely slaked and very wet.
	7	Same as well 1.

[1] The wells referred to are the 6-inch openings through the



EFFECT OF FROST ACTION ON CAPILLARY MOISTURE AT VARIOUS DEPTHS



CURVE SHOWING MOVEMENTS OF SLABS CAUSED BY TEMPERATURE STRESSES

pavements to permit examination and sampling of the soil.
[2] Well between 3 and 7.
[3] Well to right of 7.

A number of samples taken after the same freeze in an open field and on ditch banks near the experimental sections yielded moisture contents which are shown in the chart on page 31. The chart indicates very clearly that alternate freezing and thawing tends to increase surface moisture. The mild winter offered no further opportunity for the investigation of this phenomenon, but the study is now being continued by artificial methods.

At all times when the ditches were unobstructed the wettest part of the subgrade was observed to be the upper surface. The samples taken to determine the variation in moisture content were first taken at vertical intervals of 6 in., but later this interval was found to be too great, and samples are now taken at the following depths in inches: ¼, ½, ¾, 1, 2, 3, 4, 5, 6, 12, 18, and 24.

As noted in the chart on page 30, the natural rainfall was supplemented in the spring of this year by the use of lawn sprinklers placed on each section. On May 30, after about two weeks of sprinkling during which time the artificial precipitation was several times greater than the natural rainfall at any preceding time, the sprinkling was discontinued and moisture determinations were made for the several sections at various depths with the results indicated in the table below.

Percentage of Moisture at Various Depths Under Several Sections.

Depth.	Section No.									
	1	2	3	4	5	6	7	8	9	10
Inches.										
¼	26.4	25.3	26.3	24.3	21.5	20.3	22.1	19.1	20.6	20.3
½	23.3	21.4	24.3	22.1	21.3	19.8	21.5	18.5	20.4	19.9
¾	20.5	20.4	23.1	21.3	19.7	20.1	19.8	18.5	20.5	19.2
1	19.1	22.7	21.4	19.6	18.5	20.0	20.4	18.3	20.2	18.8
2	18.1	19.6	15.3	18.6	18.8	18.3	20.1	19.0	20.7	19.1
3	14.8	18.6	19.2	18.6	19.0	15.0	20.6	18.5	19.9	19.1

Moisture determinations were not made to a greater depth than 3 in., for the reason that as the depth increased the moisture content was so low that it was considered unnecessary to sample deeper. Before sprinkling was discontinued it was decided that nothing would be gained by further sprinkling, since the subgrade was not becoming any wetter and the percentages of moisture above indicated represent approximately the maximum amount of water which would be absorbed by this particular soil under the climatic condition prevailing at that time and with the construction and drainage shown.

Some idea of the movement of the pavement resulting from changes in moisture content may be obtained from the chart on page 31. At only one time during the period represented by the chart was there a frost which penetrated to the depth of the pavement. The effect of this freeze is shown on Jan. 19. The maximum observed lift on this date was 0.07 ft.

The average movement of the various pavements for the whole period was as follows:

Section No.	Average movement in thousandths of a foot.
4	14.7
[illegible]	15.1
7	18.3
3	19.3
1	19.7
9	19.8
[illegible]	22.5
5	27.7
[illegible]	27.9
10	[illegible]

The Effect of Standing Water in Side Ditches

The effect of standing water in the side ditches has been under observation since July 15, 1921, when dams were built across the lateral drains to such height that the surface of the water in these drains stood approximately 18 in. below the subgrades of the various sections. The height of the water table in the ditches has been kept constant as nearly as possible by allowing water to flow in daily except Sunday.

On August 10 the average percentages of moisture at various depths under the several sections were as follows:

Depth in Inches.	Section No.									
	1	2	3	4	5	6	7	8	[illegible]	10
	Per cent of moisture.									
0 to 3.....	19.2	19.7	18.7	20.8	15.8	14.9	20.5	19.7	19.9	17.0
0 to 6.....	19.9	19.9	18.8	20.8	16.4	14.8	20.5	19.9	19.8	17.3
0 to 24.....	20.0	20.0	19.2	20.8	17.0	16.2	21.0	20.4	20.3	18.8
18 to 24...	21.3	21.2	20.6	21.2	19.7	18.3	21.1	22.1	21.1	22.1
24 to 30...	21.9	21.7	21.1	22.2	20.3	19.8	20.4	22.7	21.6	22.4

It will be noted from the above figures that the average percentage of moisture in the subgrade increases with the depth—a condition just the reverse of that which exists when the lateral ditches are unobstructed. The flooded condition of the lateral drains will be continued for several weeks more and other moisture determinations will be made for the purpose of determining what the maximum saturation will be under these conditions.

Movements Caused by Temperature Changes

In the course of the measurement of the movement of the slabs it was noted that the elevations varied from day to day without any corresponding variation of the moisture content of the subgrade. It was thought that such changes might be due to temperature stresses in the pavement itself.

For the purpose of checking this assumption and detecting any movement which might occur very precise measurements were made every hour of the day and night across the center of section 1 and these readings together with the air temperature and the temperature of the upper and lower surfaces of the pavements are

plotted on page 31. It will be noted from this graph that the edges of the slab turn downward as the upper surface is heated and upward when the top surface temperature becomes lower than that of the bottom surface of the pavement.

The maximum change noted so far has been slightly

GENERAL VIEW OF SLABS USED FOR TESTING SUBGRADE DRAINAGE

more than 0.05 in. It will be observed that the cooling effect of the two rains which occurred during the period of observation produced rapid changes in elevations. These rather marked temperature-stress changes would indicate the need for more study and research in pavement design as well as in subgrade preparation.

AIRSHIP PHOTOGRAPHS FOR CITY AND HIGHWAY SURVEYS

Photographic maps made by piecing together many photographs taken from aeroplanes and balloons will be used for city planning and highway location, according to predictions of U. S. Army engineers. Several cities have already made plans for using these maps.

Great progress has been made in the taking of the photographs and the making of photographic maps from them at the army schools at Ross Field, Arcadia, Cal., and Langley Field, Va. At the former there has been constructed a photographic map covering an area of about 250 sq. mi., with the field as a center.

Among the uses to which such maps can be put by cities, according to the army engineers, are city planning, traffic control and fire protection. Great value is also claimed for them in the making of preliminary surveys, for railways, highways, hydro-electric projects and other engineering works. Among the advantages of this kind of mapping are its speed, its comparatively low cost, and the possibility of thoroughly covering places inaccessible by any other method.

A somewhat similar use is to be made of aeroplane photography in Paris, France. That city has just opened an air police station at Le Bourget, the aviation ground near the city. Eventually, this force will be used to control air traffic and to give chase to criminals attempting to leave the city by automobile. At first, however, one of the duties of the fliers will be to take photographs of various Paris streets and boulevards for use in the solution of the traffic problem.

ASPHALT PAVING IN 1921

By Jan. 1, 1922, a total of 65,000,000 sq. yd. of asphaltic pavement will have been laid in American cities during 1921, according to figures compiled by the Asphalt Association. This will be an increase of 25% over the yardage constructed in 1920.

Saginaw, Mich., leads all other cities this year with an increase of 600% over its yardage of last year and other cities which have shown big increases are as follows: Akron, O., 500%; Rochester, N. Y., 300%; Chicago, Ill., 60%; Des Moines, Ia., 100%; Boston, Mass., 50%; Columbus, O., 40%; Norfolk, Va., 100%; Detroit, Mich., 50%; Portland, Ore., 20%; Roanoke, Va., 60%, and San Antonio, Tex., 14%.

Greater New York has laid a total of 1,991,783 sq. yd., as follows: Bronx, 418,700; Brooklyn, 348,000; Queens, 357,843; Richmond, 118,300 and Manhattan, 503,649. The increases in the foregoing boroughs over 1920 are as follows: Bronx, 90%; Brooklyn, 10%; Queens, 55%; Richmond, 100% and Manhattan, 20%.

The asphalt paving laid and to be laid this year in other leading cities is as follows:

City	Sq. Yd.
Birmingham, Ala.	270,000
San Diego, Cal.	142,068
San Francisco, Cal.	186,648
Colorado Springs, Colo.	88,340
Denver, Colo.	151,000
Jacksonville, Fla.	75,416
Des Moines, Ia.	135,905
Chicago, Ill.	1,613,600
Indianapolis, Ind.	406,000
New Orleans, La.	155,983
Boston, Mass.	456,921
New Bedford, Mass.	176,431
Springfield, Mass.	180,250
Baltimore, Md.	660,665
Detroit, Mich.	1,295,000
Flint, Mich.	129,500
Saginaw, Mich.	120,000
St. Paul, Minn.	138,000
Kansas City, Mo.	84,915
St. Louis, Mo.	186,509
Jersey City, N. J.	108,180
Newark, N. J.	104,800
Rochester, N. Y.	325,547
Akron, O.	125,000
Cincinnati, O.	165,000
Columbus, O.	93,500
Portland, Ore.	312,336
Providence, R. I.	271,892
Fort Worth, Tex.	172,217
San Antonio, Tex.	226,000
Roanoke, Va.	87,110

Bids on "Winter Work" Projects in Minnesota carried prices considerably lower than those made last summer, according to reports of the results of lettings held late in November and early in December. The average of the bids for excavation on 7 grading jobs with a total length of 76 mi. was 23 ct., as against an average of 37 ct. on work last summer. Bids on some 260 mi. of graveling work were about half of the last summer's prices.

An Arkansas Improvement District Bond Issue of $2,225,000 of 6% bonds recently sold at a premium. The proceeds of the bonds are being used for the construction of two bridges across the Arkansas River at Little Rock.

FOUR YEARS' HIGHWAY WORK IN THE STATE OF PENNSYLVANIA

Report of the State Highway Department for 1917, 1918, 1919 and 1920 Shows a Total of $55,207,923.70 for Contracts Awarded and About 720 Miles of Road Built

Pennsylvania has built 722.45 mi. of road during the past four years and has awarded contracts for work involving a total of $55,207,923.70, according to the report of the State Highway Department for the years 1917, 1918, 1919 and 1920, now in the hands of the printer.

Of the total mileage built, 666.65 mi. were built in 1919 and 1920. The division of this mileage by types is as follows: Reinforced concrete, 536.97; brick, 47.34; bituminous surface, 73.60; sheet asphalt, 53.95; water-bound macadam, 6.85; grading and drainage, 3.74. The division by years is as follows: 1917, 8.5 mi.; 1918, 46.97; 1919, 253.10; 1920, 413.88.

Maintenance is an important part of the State Highway Department's work. General repairs were made on approximately 8,500 mi. of state highways during each of the four years. Resurfacing during each of the four years, also on state highways, included 205, 197, 218 and 349 mi., respectively. Surface treatments on state highways each year amounted to approximately 1,400 mi. Similar work was done on state aid highways, the total mileage involved amounting to about 500 mi. each year.

The appropriations made by the Legislature to the State Highway Department for construction were $6,000,000 in 1917; $4,000,000 in 1919, and $2,750,000 in 1921. Corresponding state aid appropriations were $1,500,000, $3,000,000 and $4,000,000.

The automobile license receipts are used by the State Highway Department for the maintenance of the 10,200 mi. of road comprising the state highway system. The amounts received from this source were as follows: 1917, $3,268,025.50; 1918, $4,048,185.50; 1919, $5,090,645.69; 1920, $8,090,873.04.

In 1918 the voters of the state approved a bond issue of $50,000,000. This will have been exhausted by the end of the 1922 construction season, according to the report.

The federal aid received by Pennsylvania during the four years covered by the report amounted to $8,040,698.24.

FEDERAL AID PROJECTS APPROVED

Statement of Highway Work Approved by the Bureau of Public Roads During First Quarter of the Current Fiscal Year

During the first quarter of the current fiscal year, or from July 1 to Sept. 30, inclusive, the Bureau of Public Roads approved federal aid projects in 38 states and alloted $10,389,516.58 of federal funds toward their construction. Additional projects have been approved since Sept. 30, and still others are under consideration.

The length of the projects approved during the three-month period is 1,400 mi., exclusive of a number of important bridges, which, when completed, will measure slightly more than 2 mi. in length in the aggregate. The total estimated cost of the approved projects is $25,353,848.39 and the total estimated cost of the bridges is $1,478,146.77, making the total estimated cost of all the work, $26,831,994.72. Of this entire sum, the states will pay approximately $16,500,000, or more than three-fifths of the total.

Up to the beginning of the current fiscal year, the bureau had approved projects having a total length of 35,402 mi. and a total estimated cost of about $587,321,323. Federal aid funds had been allotted to the extent of $202,764,414. These figures cover the mileage and cost of all roads approved since the inception of federal aid. Taking into account the allotments made since the beginning of the fiscal year, the bureau has approved, from the inauguration of federal aid in July, 1916, through Sept. 30, 1921, roads having a total mileage of 36,802 and costing $614,153,318. The Government has allotted towards their construction a grand total of $213,153,931, or over 34%.

The projects approved during the three months ending Sept. 30, 1921, are situated in the following states: Alabama, Arizona, Arkansas, California, Colorado, Florida, Georgia, Idaho, Indiana, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Mexico, New York, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, Washington, West Virginia, Wisconsin and Wyoming.

Most of the mileage approved consists of graded earth, sand-clay, and gravel roads, the total mileage of these three approved being 1,044.7. Their cost will amount to $10,949,286.17, it is estimated, and the amount of federal aid allotted is $4,383,995.62. Various macadam types, with bituminous macadam predominating, amount to 90.45 mi. and will cost about $2,944,771.56, of which $1,281,920.16 will come from federal funds.

Roads of the highest types to be built—cement concrete, bituminous concrete, brick, and block—will have a total length of 264.75 mi. and will cost about $11,459,790.66. Towards this cost the Government will contribute $4,012,646.35.

The total estimated cost of the bridges approved is $1,478,146.77 and the Government's share is about $710,954.45.

The Minneapolis Truck Terminals, Inc., has been organized by 15 of the principal companies and individuals operating motor truck freight lines in and around Minneapolis, Minn. The new corporation has established a union terminal from which the several truckers are operating 37 lines serving some fifty towns. The terminal is situated at 724 First Street, North.

The Supervisors of Chautauqua County, New York, recently authorized the issuing of road bonds to the amount of $1,000,000.

Equipment — Trade — Materials

NEW BULLETIN ON SNOW REMOVAL

"Caterpillar Tractors for Snow Removal" is the title of a new snow removal bulletin, No. C-168, recently issued by the Holt Manufacturing Co., of Peoria, Ill.

It consists of 8 pages, 8½x11 in. in size, printed in red and black. The contents consist of a discussion of methods of removing snow with plow-equipped "Caterpillar" tractors, together with a description of the tractor. It is profusely illustrated by half-tone reproductions of photographs of the apparatus in operation on roads and streets.

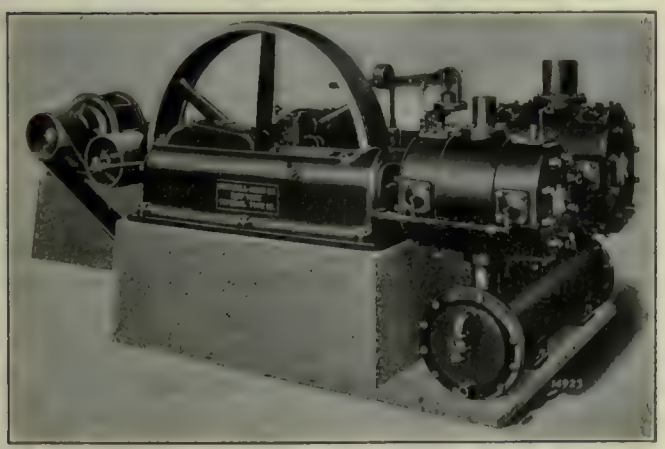
NEW INGERSOLL-RAND COMPRESSOR

A new line of belt driven air compressors, designated as the "Imperial" type "XCB," has been announced recently by the Ingersoll-Rand Co., 11 Broadway, New York, N. Y.

The machine is shown in the accompanying illustration. In it are incorporated several special features, including Ingersoll-Rand plate valves for both the air intake and the discharge, and the 5-step clearance control for regulating the compressor's output.

The plate valves used have been perfected after a complete analysis of light weight valves of that type, and they include the features that have been found necessary. The most important of these is the support of the valve throughout its entire operation in perfect alignment without any form of wearing guide.

The clearance control has been used with great success on the larger direct-connected, electric motor-driven compressors made by the Ingersoll-Rand Company. By means of it remarkably efficient operation is secured at



INGERSOLL-RAND AIR COMPRESSOR WITH SHORT BELT DRIVE AND ELECTRIC MOTOR

partial loads—an extremely important factor in view of the fact that the demand for air is seldom steady throughout the working day.

With this control the compressor is loaded or unloaded in five successive steps, the entire control being automatic. One of its especially valuable features is that the clearance pockets are integral parts of the compressor cylinder. All the mechanism for regulating the compressor is independent of the running gear.

The machine can be furnished single stage for low pressures and two stage for high pressures. The piston displacement capacity for 100 lb. discharge pressure ranges from 610 to 1,505 cu. ft. of free air per minute. The machine can also be furnished with the short belt drive attachment with floating idler.

TRUCK OPERATED PROFITABLY IN ROAD AND EXCAVATION WORK

The motor truck shown in the accompanying illustration is a 5-ton Acme machine that in 18 months of operation on road work and general excavating jobs paid

ACME 6-TON TRUCK OPERATED PROFITABLY IN ROAD AND EXCAVATION WORK

for itself and earned a "good living" for its owner, G. A. Van Dusen, of Detroit, Mich.

The truck is equipped with a 5-yd. dump body and a hoist and was purchased especially for road work. It has been used largely for that purpose, but it has also been utilized in excavating work and general hauling. During 18 months of operation it traveled 18,704 mi.

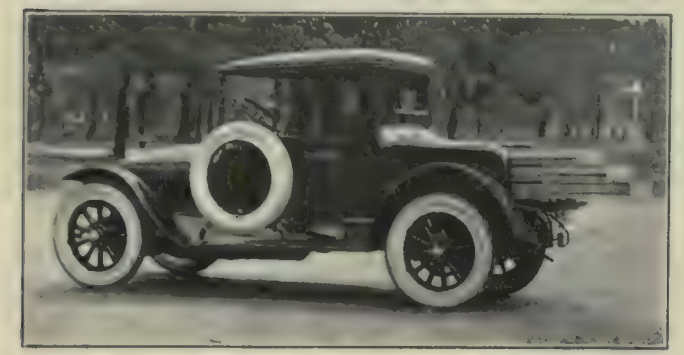
While the daily mileage averaged about 35, it varied greatly. On some road jobs the daily travel amounted to some 80 mi., while in handling building supplies and in general hauling the average was about 20 or 25.

During the year ending March 1, 1921, the truck traveled 9,456 mi. in 270 days. Based on the National Standard truck cost system, the cost of operation was $16.05 per day, that figure including $5 a day to Mr. Van Dusen for driving. It also included an allowance of $400 a year for maintenance and repairs. This gives an average cost per mile of $0.4583. The gasoline consumption was 4.5 mi. per gallon and the oil consumption 150 mi. per gallon.

WHITE BUILDS NEW TYPE BUSINESS CAR

A passenger car designed especially for the use of men whose business compels them to travel from place to place, such as contractors, engineers, salesmen and the like, is shown in the accompanying illustration.

The car is built by the White Company, the manufacturer of the truck of that name, the one pictured being one of a fleet purchased for its salesmen by a soft drink manufacturer. The machine has the appearance



NEW WHITE BUSINESS CAR

of a passenger car, but is of truck construction. This "business car," as it is called, is described by the maker as a development of the standard White taxicab chassis, with seating accommodations for two persons. It is equipped with a permanent top and there is ample room for baggage back of the seat. The rear compartment can be fitted up to carry whatever paraphernalia the user may need in his work.

ENGINEERS ADOPT FINAL PLANS FOR THE LINCOLN HIGHWAY "IDEAL" SECTION

Final plans for the "Ideal" section to be built on the Lincoln Highway were adopted by the engineers at a recent meeting at Chicago.

An agreement as to the main features of the design was reached at the meetings held in New York and in Chicago in December, 1920, and February, 1921. Since then the Lincoln Highway Association has determined, tentatively, to build the section in Lake County, Indiana, about 37 mi. south of Chicago. The cooperation of the State of Indiana has been obtained, detailed surveys of the proposed location between Dyer and Schererville, have been made, and final plans have been prepared, following the general specifications drawn by the association's technical committee.

At the recent meeting the Committee approved the detailed plans for the section prepared by Lockwood, Greene & Co., the engineers, and Consulting Engineer W. G. Thompson of the association. The plans call for a section approximately 1.75 mi. in length, consisting of a 40-ft. reinforced cement concrete pavement, 10 in .thick, laid in the center of a 100-ft. right of way. A strip 25 ft. wide at the outside of the right of way each side will be landscaped and beautified under the direction of Jens Jensen, the Chicago landscape architect. There will be no open ditches, the drainage being taken care of by tile underdrains. There will be a sidewalk for pedestrians and it will be carried across the one bridge included in the section. The road will be lighted at night, the installation of the system being made under the direction of engineers of the General Electric Co.

"It should be borne in mind that the roadway which the Lincoln Highway Association plans to construct next spring at the location mentioned was designed by its committee of experts to represent the highest possible development needed on the heaviest traveled sections of the most important highways in the United States," according to a statement from the association's headquarters. "In designing the Ideal Section, the association's technical committee had in mind an ultimate traffic volume of 20,000 vehicles per 24-hour day and assumed that 5,000 of these vehicles would be motor trucks carrying freight. While this is a traffic slightly beyond that now encountered on any road in the United States, it is not beyond that which is bound to develop on many of our most important arteries of transportation during the life of roadways laid in the immediate future. The nature of the design bears no relationship to the traffic volume now existing on the Lincoln Highway at the location tentatively selected. This location is being considered because it is central as regards the United States as a whole and convenient to Chicago, while yet being in the open country."

PARKING TUNNELS SUGGESTED FOR NEW YORK CITY

The construction of parking tunnels to relieve the congestion in the shopping and theater districts of New York City has been suggested to the Board of Estimate and Apportionment of that city by Dr. John A. Harriss, Special Deputy Police Commissioner in charge of traffic.

The tentative plan calls for the construction of underground parking spaces in Central and Bryant Parks. The former, near the 59th St. entrance, it is estimated, would accommodate 30,000 cars, while the other would take care of about 3,000. The cars would be stored in these two places while their owners were shopping or at the theaters and would be called, when wanted, by telephone. According to Dr. Harriss, practically all of the big department stores have studied the plan and are enthusiastic about it. He thinks that the cost would not be excessive.

A Three-Year Course in Road Building has been established by the Dunwoody Industrial Institute at Minneapolis, Minn. Classes are conducted during the fall, winter and spring and men are required to obtain practical work with contractors during the summer months.

The City of Dallas, Texas, is said to have refused an offer of par and accrued interest for a street improvement bond issue of $1,250,000, in the expectation of selling the bonds at a premium.

MEETINGS

Calendar of Coming Meetings

Jan. 17-19—Iowa Engineering Society.—Thirty-fourth Annual Meeting, Sioux City, Iowa. Secretary, L. A. Canfield, Des Moines, Ia.

Jan. 17-19—Associated General Contractors of America—Third Annual Meeting, Hotel Winton, Cleveland, Ohio. General Manager, R. C. Marshall, Jr., 1038 Munsey Bldg., Washington, D. C.

Jan. 17-20, 1922—American Road Builders' Association.—Nineteenth Annual Convention, Twelfth American Good Roads Congress and Thirteenth Good Roads Show under the auspices of the A. R. B. A., The Coliseum, Chicago, Ill. Secretary, E. L. Powers, 11 Waverly Place, New York, N. Y.

Feb. 12-17—Conference on Highway Engineering.—Eighth Annual Conference, University of Michigan, Ann Arbor, Mich.

STANDARDIZATION OF PAVING BRICK

Conference of Manufacturers and Users under Auspices of Department of Commerce Eliminates All but 11 of the 66 Sizes Manufactured

Fifty-five sizes and varieties of vitrified paving brick were eliminated at a conference of brick makers, brick users and other interested parties, held at Washington, D. C., on November 15, under the auspices of the U. S. Department of Commerce. The conference was the first of a series to be called by Secretary Herbert Hoover to coordinate and forward the movement to eliminate waste in industry.

The conference was opened by F. M. Feiker, Assistant to Secretary Hoover, and E. W. McCullough, Manager of the Fabricated Production Department of the United States Chamber of Commerce, was chosen to preside. Secretary Hoover addressed the meeting, explaining its purpose and calling attention to the fact that the matter of eliminating some of the 66 sizes and types of bricks had been brought to the department's attention by the manufacturers themselves.

Secretary Hoover was followed by M. B. Greenough, Secretary of the National Paving Brick Manufacturers' Association, who presented the report of that organization. The report contained a tabulation showing shipments of paving bricks of 66 varieties between 1914 and Aug. 1, 1921.

The conference then proceeded to the elimination of sizes by vote, using as a basis a maximum size of 4 (depth)x3½ (width)x8½ and a minimum size of 3x3x 8½. This resulted in reducing the number from 66 to 20. After a considerable discussion upon further elimination of varieties, a committee was appointed to take up the matter and report back to the conference at the afternoon session. The committee consisted of F. B. Dunn, President of the Dunn Wire-Cut Lug Brick Co.; L. C. Herrick, Director of Highways and Public Works, of Ohio; P. H. Bates; O. W. Renkert, of the Metropolitan Paving Brick Co.; and E. J. Mehren, of "Engineering News-Record," chairman.

At the afternoon session the committee reported back to the meeting and recommended the elimination of nine more varieties. The committee also expressed the belief that further reductions should be made and, after the adoption of the report a committee of ten was appointed to consider such further reductions. This committee consists of a representative from each of the following organizations: The American Society of Civil Engineers, the American Association of State Highway Offcials, the American Society for Municipal Improvements, the American Society for Testing Materials, the Federated American Engineering Societies, the National Paving Brick Manufacturers' Association, the United States Chamber of Commerce, the Bureau of Public Roads of the U. S. Department of Agriculture, the Bureau of Standards, and the Department of Commerce.

In order to avoid the necessity of working to exact dimensions, the following resolution was adopted by the conference:

"The sizes stated in this report are to be regarded as nominal and subject to the usual variation of ⅛ in. in width and depth and ½ in. in length."

The varieties of brick retained by the conference are shown in the following table:

	Width. (Ins.)	Depth. (Ins.)	Length. (Ins.)
Plain wire-cut brick (vertical fiber, lugless	3	4	8½
	3½	4	8½
Repressed lug brick	3½	3½	8½
	3½	4	8½
Vertical fiber lug brick	3	4	8½
	3½	4	8½
Wire-cut lug brick (Dunn)	3½	3	8½
	3½	3½	8½
	3½	4	8½
Hillside lug brick (Dunn)	3½	4	8½
Hillside lug brick (repressed)	3½	4	8½

Among those present at the conference were the following: L. C. Herrick, Director of Highways and Public Works, of Ohio, representing the American Association of State Highway Officials; R. Keith Compton, Chairman and Consulting Engineer of the Paving Commission of Baltimore, Md., representing the American Engineering Council; W. D. Uhler, Chief Engineer of the Pennsylvania State Highway Department, representing the American Society of Civil Engineers; Geo. F. Fisk, Chairman of the Committee on Brick Pavements, representing the American Society for Municipal Improvements; W. P. Blair, representing the Indiana Engineering Society; John A. Dailey, of the Department of Public Works of Chicago, Ill., representing the Western So-

ciety of Engineers; P. St. J. Wilson, Chief Engineer of the Bureau of Public Roads, representing the Department of Agriculture; H. M. McCullough, Consulting Architect of the Dunn Wire-Cut Lug Brick Co.; Harry McCreary, Road Engineer of Florida; E. J. Mehren, Editor, "Engineering News-Record"; Harry T. Shelley, Chief Engineer of the Eastern Clay Products Association; Geo. W. Tillson, Consulting Engineer of the Dunn Wire-Cut Lug Brick Co.; James C. Travilla, Consulting Engineer of the Dunn Wire-Cut Lug Brick Co.; C. C. Barr, of the Barr Clay Co.; S. M. Duty, of the Medal Paving Brick Co.; R. T. Hutchins, of the Mack Manufacturing Co.; O. W. Renkert, of the Metropolitan Paving Brick Co.; M. B. Greenough, Secretary of the National Paving Brick Manufacturers' Association; G. O. Bowles, of the Mack Manufacturing Co.; F. B. Dunn, of the Dunn Wire-Cut Lug Brick Co.; and J. W. Hall, of the Westport Paving Brick Co.

WISCONSIN ROAD SCHOOL

The annual road school of the Wisconsin Highway Commission will be held at Madison throughout the week commencing Jan. 23.

These meetings are attended by the engineers of the State Highway Department and by many county road officials. The attendance last year was about 900. It is expected that there will be an exhibition of road machinery in connection with the school.

PERSONAL MENTION

O. J. Brookshire has been appointed city engineer of Lebanon, Ind.

G. W. Courter has been appointed county engineer of Palo Pinto County, Texas.

C. E. Tilton has resigned as town engineer of Phillipsburg, N. J., effective Dec. 31.

F. R. Hodgdon has been appointed assistant to the city engineer of Joplin, Mo.

William N. Elsberg has been appointed city engineer of Minneapolis, Minn. He was formerly assistant city engineer.

H. G. Sours, Deputy County Engineer of Summit County, Ohio, has been appointed resident state highway engineer for that county.

J. Gresham, formerly county engineer of Caldwell County, Texas, has been appointed county engineer of Travis County, Texas.

L. M. Shumaker has been appointed a resident engineer of the Tennessee State Highway Department, with headquarters at Erwin.

Wm. T. Peterman, a highway contractor of St. Landry, La., has been appointed chairman of the Louisiana State Highway Commission.

C. Gray has been appointed chief engineer of the Indiana State Highway Commission. He has been acting chief engineer for several months.

L. E. Barker has been appointed engineer of the Highway Commission of Yavapai County, Arizona. Mr. Barker was formerly county engineer of Pima County, Arizona.

William C. Walker, for the past ten years construction engineer and superintendent of the Bureau of Highways of Altoona, Pa., has resigned to enter road contracting at Hollidaysburg, Pa.

E. L. Miles, County Road Superintendent of Victoria County, Ontario, Canada, has been appointed county engineer. He will continue to act as road superintendent, with headquarters at Lindsay.

Charles O. Boyd has resigned as district highway engineer of Raleigh County, West Virginia, to become resident engineer for the Carolina Engineering Co. on street work in Wilmington, N. C.

B. D. Dean has been appointed resident engineer of the inter-county bridge over the Columbia River between Pasco and Kennewick, Wash. He was formerly deputy engineer in the office of the county engineer of King County, Washington.

W. T. Chollar, formerly of the advertising department of the Atlas Portland Cement Co. and later with the Lakewood Engineering Co., is to become the eastern representative of the W. B. Conkey Co., Hammond, Ind., printers and publishers.

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The 1921 edition of this annual publication of the American Society for Testing Materials contains 127 tentative standards for the testing of materials, of which 23 relate to cement, lime, gypsum and clay products; 12 to petroleum products and lubricants; and 28 to road materials. The society's tentative standards are printed for one year or more for the purpose of eliciting criticism for the benefit of the committee concerned in the preparation of a final report embodying a specification for formal adoption by the organization.

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

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TABLE OF CONTENTS

*The Washington Bridge in Connecticut 39

Governor Miller of New York Reviews State Highway Work 40

Facing Facts in Highway Estimates 41

The Coordination of Highway Research By W. K. Hatt 45

Road Safety Essay Prizes Offered 48

Uniform Road Signs Urged 48

EDITORIALS:

Lower Construction Costs 43

Road Work in New York 43

MEETINGS:

Calendar 48

Kansas Engineering Society 48

Wisconsin Mineral Aggregate Association . . . 48

*Illustrated Article

Concrete Roads must be Reinforced

It is demonstrated beyond doubt that to make concrete roads proof against heavy motor traffic, weather and time a fabric of steel must be incorporated in the concrete.

Several great States have so ruled.

American Steel and Wire Company's

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Fulfills Every Engineering Requirement

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Good Roads that Grow Better—

MOST people are satisfied when the roads stay "as good as new." But not so the Road and Bridge Committee of Columbia County, Wisconsin.

They build good roads to start with and then, by far-sighted but inexpensive maintenance with "Tarvia-B," make those good roads better every year.

This extract from their letter will be of interest to all highway officials:

"Our experience in successfully maintaining our macadam roads with "Tarvia-B" is due not only to the excellence of your product, but also to the rule we follow in Columbia County of surface treating macadam roads in good condition and giving them additional treatments of Tarvia annually.

"During the past couple of years, we have used clean limestone screenings ¾" size as a covering after applying the Tarvia. We believe we are adding just a little more Tarvia surface each year than the traffic wears off, as we have several macadam roads in this county that have been annually treated with "Tarvia-B" for the past six years and are in better condition at the present time than they were when first treated with Tarvia."

The use of Tarvia re-enforces the road surface and makes it waterproof, frost-proof, mudless, dustless and automobile-proof. A road maintained with Tarvia pays for itself over and over again.

Tarvia is a coal-tar preparation, made in a number of grades to meet construction, maintenance and repair problems.

Illustrated booklet describing the various Tarvia treatments free on request.

Tarvia
For Road Construction Repair and Maintenance

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January 16-20, 1922.

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GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

WITH WHICH IS INCORPORATED

THE HIGHWAY CONTRACTOR AND ROAD BUILDER

Vol. LXII NEW YORK, N. Y., JANUARY 18, 1922 No. 3

The Washington Bridge in Connecticut

A large highway bridge known as the Washington Bridge has been constructed over the Housatonic River between the Towns of Milford and Stratford by the Connecticut State Highway Department. Work was started on the structure in July, 1919, and the bridge was opened to traffic on Nov. 11, 1921. This bridge is of the open spandrel reinforced concrete type, and is the first bridge in the state to be supported on concrete piles. From end to end the superstructure is 867.33 ft. long, consisting of two girder approach spans, five 100-ft. ribbed arch spans and one 175-ft. steel double leaf bascule span.

The decking of the bridge is 63 ft. in width and is supported on columns resting upon the backs of the arch ribs on the main part of the bridge. There are two 8-ft. sidewalks and a 43-ft. roadway, the latter carrying a double-track trolley. The paving on the draw span is wood block, and that on the rest of the bridge a 3-in. asphalt pavement. The handrail is of the open panel type, cast in place and consisting of a 1:2½:½ mixture of cement, granite chips and copper furnace slag. An ornamental house on brackets will be placed on each draw pier, one to be used for the operation of the bascule span and the other for a comfort station.

In building this bridge, 25,000 cu. yd. of concrete were placed, with 1,250,000 lb. of reinforcing steel, which came to the job bent and ready to place. The centering used for the arches was of light steel truss construction, supported in place only at the ends next to the piers on timbers, striking wedges and posts. Forms for the concrete were made in panels in the sawmill and set up and braced in place on the job. The bascule span includes 1,626,000 lb. of structural steel.

In the foundations there are 1,565 concrete piles, ranging in length from 24 to 49 ft. These were cast on the job and sunk in place by jetting and hammering to rock or to refusal. For sinking the piles a driver was used equipped with steel extension leads and a 30-ft. oak follower attached to a 5-ton steam drop hammer. In conjunction with the hammer a powerful jet was used. As many as 34 piles were put down in an 8-hour shift. The cut off elevations for the heads of the piles were at —20 for the west abutment, —32 for the draw piers and —24 for piers Nos. 1 and 4. Pier No. 5 and the east abutment rest directly on rock. The concrete in the footings among the pile heads and up to an elevation of —6 was placed

ARCH FORMS IN PLACE—WASHINGTON BRIDGE

ONE OF THE PIERS OF THE WASHINGTON BRIDGE

by tremie; then the cofferdams were unwatered and the balance of concrete placed in the dry.

Construction operations on this bridge proceeded as follows: First the excavation for the pier footings was made. Where piles were to be used, excavation was carried deeper to allow for the displacement of the piles. Material excavated and found suitable for fill was placed in the embankments at the ends of the bridge; unsuitable material dredged was dumped at sea. After the piles in one footing were all in place, they were enclosed by driving a steel cofferdam around them.

In the placing of the underwater concrete, a tremie was used with a 1:2:3 mix. This tremie was constructed on the job and consisted of 12-in. flange jointed pipe with a sheet steel hopper at the top or above the water end, and was suspended from two 10-ton chain falls used to operate the tremie. These chain falls were made fast to timbers on a storage hopper of 4 cu. yd. capacity whose discharge gate opened into the tremie hopper. The tremie was so located on the side of the storage hopper as to permit the removal of the tremie by raising it with the derrick. The storage hopper was built on skids and moved about on carrying timbers across the cofferdam. The consistency of the concrete was kept as stiff as would flow through the discharging gate of the storage hopper.

In operation the tremie was raised clear of the water and a wooden cap made of two 1-in. boards with a ring of rubberoid for a gasket was placed over the end to be submerged, this cap being kept in position until the tremie was lowered beneath the surface of the water, when the pressure kept it in place. Then the tremie was filled with concrete and raised slightly by the chain falls, thus permitting concrete to flow out slowly at the bottom. The tremie was kept filled from the storage hopper. By this method concrete was placed at the rate of 200 cu. yd. a day. When the cofferdams were unwatered the concrete showed very little laitance. After the water was lowered, the concrete was washed immediately with a hose.

A floating mixing plant supplied concrete to the job. Sand and stone were received from scows and the mixer discharged into bottom dump buckets of 1 cu. yd. capacity which were handled to place by means of a derrick on a lighter nearby. After placing the concrete up to an elevation of —6, where the dams were unwatered, the concrete was placed in them up to —2, where the granite facing begins and where the mix changed to 1:3:5. The granite was laid up and backed with concrete, two courses at a time, up to the spring line of the arches, at +11 elevation. Here the superstructure begins and the mix was changed to 1:2:4. Each of the arch spans consists of six reinforced concrete ribs.

Centers for two complete spans of six ribs each were used on the job. One set was used twice; the other three times. These centers were set up in place by a lighter and upon them the rib forms set up and the reinforcing placed. The column basis on the backs of the arch ribs were cast with the rib. Two or three ribs were poured in one span before pouring the ribs in the next span. The centering was left in place 28 days in the first three spans and 21 days in the other ribs.

While the centers were in place and after the ribs were poured, the column beam and decking forms were set up; then the columns were poured up to the beam bottoms. After the centers were lowered the beams and decking were poured. Concrete in the ribs was chuted in place;

THE WASHINGTON BRIDGE CARRYING THE BOSTON POST ROAD

that in the columns, beams and decking was placed by buggies. After the roadway decking was completed, the curbs, sidewalks and base of handrails were poured.

The bridge was built under the direction of the State Highway Department and under the direct supervision of Division Engineer E. C. Welden. John Smith was the resident engineer, reporting to Mr. Welden.

GOVERNOR MILLER OF NEW YORK REVIEWS STATE HIGHWAY WORK

In his annual message to the New York Legislature on Jan. 4, Governor Miller reviewed the road work done in the state in 1921 as follows:

"During the past year 618 mi. of new state highways have been constructed as compared with 246 mi. the year before; 202 mi. reconstructed as compared with 99 mi. the year before, and 7,479 mi. maintained as compared with 7,259 mi. the year before. There are 395 mi. of roads needing reconstruction and it will be necessary to construct 2,257 mi. of new roads to complete the connected system of state roads of 11,300 mi. adopted by the legislature last year. The bond moneys for new construction will be practically exhausted this year. Unless a referendum to issue additional bonds be submitted to the people, which I do not advise, it will be necessary to complete the system from current revenues. That will mean a considerable increase for a number of years in the appropriation for new construction as well as for maintenance. That increase will have to be met either from an increase in revenues from some appropriate source or by direct tax. That work has been prosecuted during the past year with unremitting vigor and there should be no relaxation of effort to complete the highway system of the state. A completely improved system of state highways with the development of motor transport will help solve our problems of transportation and food distribution."

Facing Facts in Highway Estimates *

Standard Estimate of Cost Forms Prepared and Advocated by the Kentucky Association of Highway Contractors to Facilitate the Making of Road Work Estimates

What is cost? What is profit? The first contractor answers: "Cost is labor and materials. Profit is the remainder of the contract price." Wrong.

The second contractor says: "Cost is every item of expense that I incur on my job. Profit is the remainder of the contract price." Right.

The cost of an item is the sum of the expenses involved in its production up to the moment at which cost is determined.

Profit is that part of the contract price which remains after the cost has been deducted.

These are fundamental principles of cost engineering and must be borne in mind by the contractor who is to make a success in his business.

Every contractor, as every factory and merchant, needs some one in his organization to ascertain absolutely his cost to produce every item entering into his business; not to guess for him what that item will cost in the next job, but to tell him what it *did* cost in the last job or in the last two or three or ten jobs. It is impossible for the Association to do this for every member, but it is possible to furnish him the means whereby he may accurately and definitely estimate what the next job will cost when he has definite knowledge of the cost of his last job.

Facing the Facts

For this purpose we have prepared a Standard Estimate-of-Cost Form which is being distributed to members of the Kentucky Association of Highway Contractors and to other contractors doing business in the State of Kentucky. This form is not put out as a perfect article, but does purport to be the best that is available at this time. It is so arranged as to cover each of the major operations entering into road construction in such detail that the estimating of a job is almost automatic if the bidder knows the proper amounts to place in the blanks. In this form it is attempted to place squarely before the bidder every item of cost which is ordinarily encountered, but if he does not make provision in his estimate for each item listed as well as for every unusual item not listed, he is simply placing himself in the class of the ostrich that buries its head in the sand in an effort to conceal itself. In reality he fools nobody but himself.

Remember this: No estimate is complete that does not take into consideration every element of expense that will immediately or eventually be considered as part of the cost. Everything is cost except the money the job puts into your pocket after all expenses are paid. Round numbers are the cloak of ignorance; definite figures form the basis of action.

*From the "Bulletin" of the Associated General Contractors.

Class of Work	A Cost per Unit	B Quantity	C Total Cost *
1. Clearing and Grubbing			
(a) Foreman, per day	$.....		
(b) Men, ...at $....per day			
(c) Men, ...at $....per day			
(d) Men, ...at $....per day			
(e) Teams, ...at $....per day			
(f) Explosives (include freight, tax and haul)			
(g) Equipment operation			
Daily operating expense	$.....		
(h) Multiply by no. of days to clear and grub			
	$.....		
(i) Add proper per cent of operations 14 and 15			
Net cost of operation 1	$.....		
Divide by .... acres.			
Net cost per acre	$.....		
Net profit .... per cent			
Bid price per acre	$.....		
2. Pipe Culverts			
(a) Earth excavation, ... cu. yds. at $.....	$.....		
(b) Rock excavation, ... cu. yds. at $.....			
(See operations 4 and 5.)			
(c) Pipe, ... ft. at $.... F.O.B.			
(d) Pipe, ... ft. at $.... F.O.B.			
(e) Pipe, ... ft. at $.... F.O.B.			
(f) Breakage			
(g) Freight and war tax			
(h) Unloading and hauling to job			
(i) Laying, ... ft. at $....			
(j) Sand, ... tons at $....			
(k) Cement, ... bbls. at $....			
(l) Backfilling, ... cu. yds. at $....			
(m) Temporary detours			
(n) Proper per cent of operations 14 and 15			
Net cost of operation 2	$.....		
Divide by .... lin. ft.			
Net cost per lin. ft	$.....		
Net profit, ... per cent			
Bid per lin. ft	$.....		
3. Timber Piles			
(a) Foreman, per day	$.....		
(b) Men, ... at $ per day			
(c) Men on leads, ...at $.... per day			
(d) Engine man, per day			
(e) Fireman, per day			
(f) Fuel, il, etc., per day			
Daily operating expense	$.....		
(g) Divide by average daily output.			
(h) Operating expense per lin. ft	$.....		
(i) Piles, ... ft. at $....	$.....		
(j) Freight and war tax			
(k) Unloading and hauling			
(l) Preparing stick, ... ft. at	$.....		
(m) Cutting off .... piles at $....			
(n) Moving equipment between setups			
(o) Add .... per cent of operations 14 and 15			
Total of (i) to (o)	$.....		

*In each operation the total in Column A multiplied by the total in Column B equals the total in Column C.

	A	B	C
Divide by .... lin. ft.			
Add to (h).....$.....			
Net cost per lin. ft.....$.....			
Add loss of cut-off (not measured).....			
Total cost per lin. ft.....$.....			
Net profit, ... per cent.....			
Bid price per lin. ft.....$.....			
4. Earth Excavation (if wet, add pumping, cofferdam, etc.)			
(a) Foreman, per day.....$.....			
(b) Men, ... at $.... per day.....			
(c) Men, ... at $.... per day.....			
(d) Men, ... at $.... per day.....			
(e) Teams, ... at $.... per day.....			
(f) Snatch team, ... at $.... per day.....			
(g) Plowing, per day.....			
(h) Loading, per day.....			
(i) Hauling, per day.....			
(j) Dumping, per day.....			
(k) Lost time on (h), (i) and (j) per day.....			
(l) Equipment operation per day.....			
Daily operating expense.....$.....			
(m) Divide by average daily yardage.			
(n) Operating expense per cu. yd.....$.....			
(o) Staking entire job.....$.....			
(p) Clear and grub (not in operation 1).....			
(q) Sloping, ... ft. at $.....			
(r) Trimming, ... ft. at $.....			
(s) Shoulders, ... ft. at $.....			
(t) Ditching, ... ft. at $.....			
(u) Rolling, ... days at $.....			
(v) Add per cent of operations 14 and 15			
Total of (o) to (v).....$.....			
(w) Divide by .... cu. yds.			
(x) Add to (n).....$.....			
Net cost per cu. yd.....$.....			
Net profit, ... per cent.....			
Bid price per cu. yd.....$.....			
5. Rock Excavation (if wet, add pumping, cofferdam, etc.)			
(a) Foreman, per day.....$.....			
(b) Men, ... at $.... per day.....			
(c) Men, ... at $.... per day.....			
(d) Men, ... at $.... per day.....			
(e) Teams, ... at $.... per day.....			
(f) Stripping, per day.....			
(g) Equipment operation, per day.....			
(h) Explosives (include freight, tax and haul)			
(i) Protecting shots, per day.....			
(j) Sledging and loading, per day.....			
(k) Hauling, per day.....			
(l) Pumping, per day.....			
Daily operating expense.....$.....			
(m) Divide by average daily yardage.			
(n) Operating expense per cu. yd.....$.....			
(o) Staking entire job.....$.....			
(p) Clear and grub (not in operation 1).....			
(q) Trimming, ... ft. at $.....			
(r) Ditching, ... ft. at $.....			
(s) Add per cent of operations 14 and 15			
Total of (o) to (s).....$.....			
(t) Divide by .... cu. yds.			
(u) Add to (n).....$.....			
Net cost per cu. yd.....$.....			
Add per cent for overbreakage (not measured)			
Total cost per cu. yd.....$.....			
Net profit, ... per cent.....			
Bid price per cu. yd.....$.....			
6. Cement			
(a) Gross price per bbl.....$.....			
(b) Credit sacks....$.... per bbl.			
(c) Credit discount, $.... per bbl.			
(d) Total credits,....$....deduct $.....			
$.....			
(e) Add sack loss per bbl.....			
(f) .... bbls. cement at.....$.....$.....			
(g) Freight and war tax.....			
(h) Unloading and hauling to job.....			
(i) Storing and rehandling .... bbls.....			
(j) Return freight and tax on sacks.....			
(k) Demurrage			
(l) Waste, ... per cent.....			
(m) Add per cent of operations 14 and 15....			
Nét cost of operation 6.....$.....			
Divide by quantity .... bbls.....			
Net cost per bbl.....$.....			
(Do not add profit here.)			
7. Sand or Fine Aggregate (see also Operation 9)			
(a) .... tons at $..... .....$.....			
(b) Freight and war tax.....			
(c) Demurrage			
(d) Unloading and hauling to job.....			
(e) Rehandling from stock pile.....			
(f) Waste .... per cent.....			
(g) Add per cent of operations 14 and 15....			
Net cost of operation 7.....$.....			
Divide by quantity .... tons.....			
Net cost per ton.....$.....			
(Do not add profit here.)			
8. Gravel, Stone or Coarse Aggregate (see also Operation 9)			
(a) .... tons at $..... .....$.....			
(b) Freight and war tax.....			
(c) Demurrage			
(d) Unloading and hauling to job.....			
(e) Rehandling from stock pile.....			
(f) Waste .... per cent.....			
(g) Add per cent of operations 14 and 15....			
Net cost of operation 8.....$.....			
Divide by quantity .... tons.....			
Net cost per ton.....$.....			
(Do not add profit here.)			
9. Quarrying and Crushing			
(a) Foreman, per day.....$.....			
(b) Men, ... at $.... per day.....			
(c) Men, ... at $.... per day.....			
(d) Men, ... at $.... per day.....			
(e) Teams, ... at $.... per day.....			
(f) Equipment operation, per day.....			
(g) Explosives (including freight, tax and haul)			
(h) Protecting shots, per day.....			
(i) Sledging and loading, per day.....			
(j) Hauling, per day.....			
(k) Pumping, per day.....			
Daily operating expense.....$.....			
(l) Divide by average daily tonnage.....			
(m) Operating expense per ton.....$.....			
(n) Clear and grub(see operation 1).$.....			
(o) Stripping			
(p) Add per cent of operations 14 and 15			
Total of (n) to (p).....$.....			
(q) Divide by .... tons.....$.....			
(r) Add to (m).....$.....			
Net cost per ton.....$.....			
(Do not add profit here.)			
10. Reinforcement			
(a) Reinforcement, ... lbs. at $.....$.....			
(b) Freight and war tax.....			
(c) Unloading and hauling.....			
(d) Rehandling from stock pile.....			
(e) Cutting			
(f) Bending			
(g) Add per cent of operations 14 and 15....			
Net cost of operation 10.....$.....			

(Continued on page 44)

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

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E. L. POWERS
Editor

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LOWER CONSTRUCTION COSTS

In keeping with the general recession of prices, road construction costs during the past year have been materially reduced. This fact, in conjunction with the more favorable money situation and the consequent ability of states and counties to market their bonds with comparative ease, makes the outlook for increased road work for the coming year exceedingly bright. In the beginning of 1921, the country had not yet recovered from its intoxication of high prices and excessive money rates, and the political subdivisions of this country experienced considerable difficulty in marketing many million dollars of road and bridge bonds, and if they did market their bonds, they were confronted by abnormal high construction costs. Toward the middle of the year interest rates and construction costs began to recede, and while much road work was able to be accomplished, the delay experienced in the first part of the season greatly diminished the total amount of road work that would have been done had more favorable conditions obtained in the first quarter of 1921.

A concrete example of how greatly road construction costs have receded during the past year is given by Clifford Older, Chief Highway Engineer of Illinois, in last week's issue. Mr. Older says:

"A general idea of the downward trend of road construction costs since the first Illinois letting last year, held in February, may be gained from the fact that the price of pavement at that time averaged $2.36 per square yard without cement, whereas at the letting held on Oct. 4, 1921, the price per square yard averaged $1.70 without cement. The average cost per mile for concrete pavement, including cement, was $39,120 on Feb. 18, 1921; on Oct. 4 this was reduced to $28,540 per mile. Excavation prices have been reduced from 56 ct. per cubic yard average price on Feb. 18 to 26 ct. per cubic yard average price on Oct. 4. Class A concrete has been reduced from $26.29 per cubic yard on Feb. 18 to $16.83 per cubic yard on Oct. 4. A comparison of these same lettings shows that reinforcing steel has been reduced from 6.1 ct. per pound to 3.94 ct. per pound, and structural steel from 7.7 ct. per pound to 5.2 ct. per pound."

These reductions in road and brige construction costs in the case of Illinois amount to nearly forty per cent. Thus, where it was possible to build a mile of road a year ago, it is now possible to build close to two miles at the same price. Similar reductions in road construction costs are reported from all parts of the country, and as a result of the greatly lowered prices, states and counties are preparing large road programs for 1922.

ROAD WORK IN NEW YORK

During 1921 the State of New York constructed 618 mi. of highways, according to the annual message of Governor Miller to the State Legislature on Jan. 4, as compared with 246 mi. constructed in 1920. This increase of road building activity is typical of most of the states of the Union, each year more money is being spent to improve the highways in the United States.

A problem which is common to many states, is pointed out by Governor Miller, in connection with ways and means for financing new improvements. Governor Miller says: "The bond moneys for new construction will be practically exhausted this year and unless a referendum to issue additional bonds be submitted to the people, which I do not advise, it will be necessary to complete the system from current revenues. That will mean a considerable increase for a number of years in the appropriation for new construction as well as maintenance. That increase will have to be met either from an increase in revenues from some appropriate source or by a direct tax."

The problem of financing highway work is becoming more important each year. Many states, like New York, have issued large amounts of road bonds, on which they are paying interest and retiring the principal. The issuing of road bonds may well be used as means for a state to secure funds quickly with which to start the construction of a system of improved highways, but since the interest on the bonds often doubles the cost of the roads built, if the state can avoid issuing additional bonds, its highway system will be constructed at much less cost. The suggestion of Governor Miller, that no new road bonds should be issued, but that funds for future road work should be secured by "an increase in revenues from some appropriate source or by a direct tax," is a matter which ought to be carefully weighed by other states before issuing large amounts of road bonds.

FACING FACTS IN HIGHWAY ESTIMATES

(Continued from page 42)

	A	B	C
Divide by quantity .... lbs.....			
Net cost per lb.....$.....			
Net profit ....per cent.....			
Bid price per lb.....$...			

11. Concrete—In Bulk

(a) *Cement .... bbls. at $.....$.....			
(b) *Sand .... tons at.....			
(c) *Gravel .... tons at $.....			
*Table 2.			
(d) Water .... gals. at $.....			
(e) Waterproofing .... lbs. at $.....			
(f) Labor			
(g) Concrete .... cu. yds. at $.....$.....			
(h) Moving equipment between setups.....			
(i) Drains .... lin. ft. at $.....			
(j) Expansion joints .... ft. at $.....			
(k) Lumber .... ft. B. M. at $.....			
(l) Freight and war tax on lumber.....			
(m) Unloading and hauling to job.....			
(n) Contract labor .... sq. ft. at $.....			
(o) Hardware .... lbs. at $.....			
(p) Paraffine oil, etc.....			
(q) Wrecking and cleaning forms sq. ft.... at $.....			
If in concrete price, add following:			
(r) Excavation .... cu. yds. at $.....			
(s) Backfilling .... cu. yds. at $.....			
(t) Finishing .... sq. ft. at $.....			
(u) Curing ... men at $... per day ... days			
(v) Curing .... water .... gals. at $.....			
(w) Add per cent of operations 14 and 15.....			
Net cost of operation 11.....$.....			
Divide by quantity .... cu. yds.....			
Net cost per cu. yd.....$.....			
Net profit ....per cent.....			
Bid price per cu. yd.....$.....			

(If not more than one class to be estimated, use additional blanks.)

(To convert from cu. yd. to sq. yd., see table 3)

12. Stone Base

(a) Stone (operation 8 or 9) $.... per ton..$.....			
(b) Rehandling from stock or bin, $.. per ton			
(c) Spreading, $.... per ton.....			
(d) Watering (labor, teams and water) $.... per ton			
(e) Rolling, $.... per ton.....			
(f) Waste .... per cent $.... per ton.....			
(g) .... tons at $.... per ton.....$.....			
(h) Preparation of subgrade, labor and teams			
(i) Add per cent of operations 14 and 15.....			
Net cost of operation 12..... $.....			
Divide by quantity .... tons.....			
Net cost per ton.....$.....			
Net profit ....per cent.....			
Bid price per ton.....$.....			

13. Wearing Surface

(a) Surface material	..tons at $....Gross $.....		
	..gal. at $....Disct.		
	..M at $.... Net $.....		
(b) Freight and war tax.....			
(c) Unloading and hauling.....			
(d) Rehandling from storage.....			
(e) Applying or laying ....tons / ....gal. / ....M. at $.....			
(f) Dry mortar bed.... tons sand at $.....			
(g) Dry mortar bed .... bls.....			
Dry mortar bed—— cement at $.....			
(h) Dry mortar bed.... labor.....			
(i) Rolling ... days at $.....			
(j) Expansion joints .... ft. at $.....			
(k) Routing .... sq. yds. at $.....			
(l) Demurrage			
(m) Waste .. per cent.....			
(n) Add per cent of operation 14 and 15.....			
Net cost of operation 13.....$.....			
Divide by quantity ....tons / ....gals. / ....sq. yds.			
Net cost per unit.....			
Net profit			
Bid price per ton / gal. / sq. yds. .....$.....			

14. Job Overhead (expense incurred directly on account of this job)

(a) Rental of land, buildings and water supply .....$.....			
(b) Construction or rental of tracks and trestles			
(c) Hauling and loading equipment, supplies and teams			
(d) Freight and war tax on same.....			
(e) Unloading and hauling to job.....			
(f) Lost time of equipment in transit days at $			
(g) Erection and moving of camp, including water supply, bins, crushers, equipment, etc.			
(h) Return of equipment to storage (from all-season job or last job of season)....			
(i) Cost of all hand tools.....			
(j) Hiring and transporting labor.....			
(k) Loss on camp operation.....			
(l) Building and maintaining temporary roads and detours.....			
(m) Inconvenience and keeping road open to travel			
(n) Maintaining road until acceptance.....			
(o) Insurance, compensation and public liability			
(p) Insurance, fire (on job only).....			
(q) Insurance, payroll (on job only).....			
(r) Insurance, tornado (on job only).....			
(s) Insurance, other (on job only).....			
(t) Contingencies—delays due to railroad embargoes, fires, strikes, breakdowns, failure of water supply, unusually bad weather, etc.			
(u) Equipment rental charge (Table 1*)...			
(v) Wages of superintendent, material clerk, time-keeper, water boy, watchman and all regular employees on this job not charged above.....			
(w) Travelling (including auto) and hotel expense			
(x) Bond 1½ per cent of amount of bid.....			
(y) Association fee			
(z) Discount on warrants—interest on notes.			
(aa) Patent royalties			
(ab) Other job overhead.....			
Net cost of operation 14.....$.....			

(Do not add profit here.) Be sure total cost of job overhead is distributed in Operations 1 to 13

15. General Overhead

.... per cent of amount of bid..... .....

(Expense of doing business, whether you get this job or not. General Overhead is expressed as a percentage of your average annual business income. Thus, if your contracts in an average year are $500,000.00 and the operation of your main office, regular monthly employees, and fixed expenses off the job is $25,000 your overhead is 5 per cent. You should then include in every bid a cost item of 5 per cent of the amount of your bid to reimburse you for general overhead. This is part of your COST and not of your profit. See suggested list of General Overhead Items following Table 4.) Be sure total cost of General Overhead is distributed in Operations 1 to 13.

Net cost of Operations 1 to 15 (exclusive of profit)..... .....

*See "An Official Rental Schedule," The Bulletin of the A. G. C., February, 1921, Supplement, pages 48 and 49.

	A	B	C
RECAPITULATION (Use only to check Bond, Association Fee, General Overhead, etc.)			
Net cost of Operations 1 to 15 (exclusive of profit)...$			
Net cost of other items bid on (not included above)			
Total net cost of job...$			
Net profit .... per cent			
Total amount of bid...$			
(See if bond, Association fee, General Overhead, etc.—Operations 14 and 15—represent proper percentage of total amount of bid.)			

*See "An Official Rental Schedule," The Bulletin of the A. G. C., February, 1921, Supplement, pages 48 and 49.

TABLE 2

Quantities of Loose Material for a Cubic Yard of Concrete

(1 bbl. cement equals 4 cu. ft.—percentage of voids 45 per cent)

Class of Concrete	Cement	Sand	Gravel or broken stone
	Bbls.	Cu. yds.	Cu. yds.
Class A	1.51	0.45	0.89
Class B	1.24	0.46	0.92
Class C	1.06	0.47	0.94
Class D	1.74	0.52	0.77
Class E	1.74	0.52	0.77

(No allowance made for waste.)

TABLE 3

1 cu. yd. concrete=9.00 sq. yds. if 4" deep.
1 cu. yd. concrete=7.20 sq. yds. if 5" deep.
1 cu. yd. concrete=6.00 sq. yds. if 6" deep.
1 cu. yd. concrete=5.14 sq. yds. if 7" deep.

TABLE 4

Some of Items to be Included in Determining General Overhead

(See Operation 15)

(Analyze your own business for additional items.)

	Total for year
Acquisition of new contracts (include railroad and hotel expenses)...$	
Advertising	
Automobile expense, maintenance and depreciation	
Bad accounts	
Depreciation and obsolescence of buildings (not job buildings)	
Donations	
Dues to business organizations	
Insurance on buildings (not job buildings)	
Insurance, public liability and compensation on office force and executives	
Insurance, boiler	
Insurance, corporation	
Interest on invested capital (not including equipment)	
Interest on borrowed money	
Interest on accounts overdue	
Interest on cash in bank	
Licenses	
Licenses	
Main office expense—rent, light, heat, water, toilet supplies, telephone, telegrams, printing, stationery, postage, trade magazines	
Maintenance and repairs of buildings (not job buildings)	
Plans	
Salaries of officers and executives (not in item (v) operation 14)	
Salaries for fees of legal advisers	
Salaries and wages of employees in main office	
Taxes, income and profits	
Taxes, corporation	
Taxes, real estate	
Taxes, personal property	
Other general overhead costs	
Total general overhead...$	
Divide by average annual business income your general overhead	

The Coordination of Highway Research*

By W. K. HATT†

The methods of science depend upon measurement and instruments, and training in the use of them. I have been told that the beginning of modern road construction in this country coincided with the return of the late Professor Shaler of Massachusetts from France with certain instruments devised for the testing of road material. These instruments were also the introduction to highway engineering of the late Logan Waller Page, afterward the head of the Office of Public Roads.

I do not wish to say that the data of research will solve all highway problems, because some of the elements are not to be measured, such, for instance, as community welfare, safety and social values. Indeed there are regions where road expenditures justify themselves even if not one ton of freight were hauled over the roads. But yet the commercial traffic in freight truck and high speed passenger bus service is now with us, and the consequent problems are within the realms of science.

Men charged with the responsibility for the wise expenditure of vast public funds, and functioning, as at times they do, both as administrators and as engineers, and creating a new and rapidly growing branch of civil engineering will, however, be interested in the discussion of highway research, whose function it is to gather together in a systematic and disinterested way that information upon which highways may be built which will be suitable to the physics of the situation and which will represent capital wisely invested rather than consumed, also economical in the end.

The National Research Council

The National Research Council was created during the World War to mobilize the inventive genius and the research workers for the more rapid development of instruments of scientific warfare. After the war the Research Council was perpetuated by executive order of President Wilson, and attached to the National Academy of Sciences, which itself was incorporated after the Civil War by federal charter as an institution of reference, available to the Government for the settlement of scientific questions. This Research Council does no research work directly, but supports and encourages research and coordinates. It does not prepare standards or formulate specifications. It is organized into divisions representing

*Extract of paper presented at annual meeting of American Association of State Highway Officials.

†Director, Advisory Board on Highway Research, National Research Council.

the various mechanical and natural sciences, including engineering, one each of which is represented by appropriate national societies. On the Advisory Board on Highway Research of the Division of Engineering are represented those societies that deal with the vehicles as well as with the road, and the federal departments. The chairman is Dean Marston, a member of the Highway Commission of Iowa, and James H. MacDonald, Chief of the Bureau of Public Roads, is a member of the Executive Committee.

I shall assume, therefore, in advance, your support of Highway Research and also your knowledge of the various parts of the field of highway research, namely, economics, operation, design and construction, in each of which data must be secured. A chart of this has been shown and discussed in the magazine *Public Roads*, published by the Bureau of Public Roads, from which the complexity of this field may be evident.

The Nature of Research

Allow me to mention one by-product of research work, namely, the bringing together of men of apparently conflicting interests and those in controversy arising from misconception. Against the background of research, and a common effort to determine facts, acrimonious disputes are quieted, mere opinions are held in abeyance under the benign influence of the research for truth. The promoter and salesman drift into the background.

Then, too, how often has one of us seen foremen or inspectors quickened to greater vigilance and study when standard tests are applied to a material like concrete, and relative workmanship of operators is shown by some standard like the results of tests of field cylinders.

Research work when confined to the laboratory may be incomplete, often barren, and has been at time misleading. Something more than routine reception and control tests of materials is needed in a complete program. Research is something more than a demonstration to prove a theory or support an argument as in a law suit. It is as big as outdoors, and needs the cooperation of the engineers of design and construction as well as the testing expert.

The researcher, also, may proceed by statistics when he determines maintenance and other operating costs of road and vehicle, collects data of accidents and conducts traffic studies.

We have in the past confined our attention too closely to the materials of construction. Now we are alive to the need for research on the more extensive element of highway transport, the vehicle, and on the mutual relations of the vehicle and the road.

The simplest class of research is that wherein the influence of a certain element upon a result is sought, as for instance, the effect of water-content upon the strength of mortar, or of speed of operation of the testing machine upon the strength of steel, or of bitumen-content upon the penetration test. Such work demands a carefully prepared working plan and systematic operations and known conditions. The tester knows in advance the element he has to deal with, and by a mechanical process arranges his tests so as to isolate each variable element and allow it to operate on the results. Of this class is also the work of standardizing methods of tests, so that operators in different laboratories may accept or reject materials uniformly. This class of experimenting is within the reach of a careful man with technical training, and demands only ordinary research ability. Here lies a useful field of work for the testing department of the state commissions in the winter time—to develop significant tests for new materials and study their nature.

A somewhat more difficult class of test is that in which a construction is submitted to loads like those of service to determine either mechanical principles operating or else empirical coefficients to aid the designer. The class requires a higher research ability and experience, more imagination, a keener analysis, and an organizing ability.

For example, the experimental road two miles long designed by Clifford Older, Chief Highway Engineer of Illinois, and the Pittsburg Steel Company, and engineered by Messrs. Leonard and Aldrich, of San Francisco, are attempts to subject a variety of types of pavement to an accelerated test and show a very high degree of scientific technique. At Pittsburg the traffic amounts to 10,000 trucks a day, at an operating expense of $500 a day; the total expense may amount to $150,000.00. An example that came under the speaker's observation was the oval track near Berlin, Germany, where in three months service any railway track could be evaluated.

One aspect of tests of field construction on a large scale presents a difficulty in that these tests are in the public eye, and are often of an experimental nature in which constructions are loaded with a view to failure. These expected failures may be twisted by interested persons to mislead the layman, and be represented as a normal case. Again, in such tests of construction, but which become evident for the first time and which we know permit the designer to provide for them intelligently. And yet these deformations may be wrongly used as an argument against the type under study, rather than as a basis for improved designs of this type. It is this aspect of experimental roads which may explain the reluctance of producing interest to cooperate in such research work.

The large scale experiments demand cooperation between industry, the engineer and the trained researcher. There is always a danger of attempting too much. The program is subject to a change of plan during the test, because apparently no one is wise enough to foresee all conditions, in an unknown field. Yet with all these drawbacks, probably the most useful field of research is in the examination of the fundamental laws governing the behavior of constructions. A fruitful field of research is on subsoils, finding out what characteristic of each soil it is that determines its properties and evaluating them so that an engineer can examine a soil and then intelligently design a road to carry the load over the soil, or know what to do to improve its supporting power.

Another example is the study of the laws of deformation of stiff slabs under loads, and the methods of reinforcing these economically.

It appears to the speaker that experiments on a large scale are necessary in each locality. The conditions of soil, climate and available materials are so different in this wide country that the findings of one state cannot be used entirely in another. The skilled engineer is needed to design a road as he designs anything else. Just now he is forced to work without adequate data.

An interesting and valuable field of research, also, is in the department of maintenance, not only for a correct principle of maintenance for each type, but also in the economics of maintenance.

Finally the research data must be obtained by disinterested agencies, by scientists who do not sell an idea to themselves, by trained experimenters who know from their experience the many pitfalls and blind alleys in this field. A part of our present data is incomplete, and belongs in the discard. Truth does not grow on every bush to be picked by the passer-by.

In the course of a rapid survey of the field in the States of Connecticut, Pennsylvania, Michigan, Illinois, Wisconsin, California and Washington, I have become aware of very substantial and praiseworthy research activities in the state organizations, and of the existence of a large mass of research data, much of which should be uncovered for the benefit of all. As it is now there seems to be no well defined channel of communication between the state highway commissions in respect to information of research, and of experiences in this rapidly growing field. It is not too much to say that decisions involving large sums of money are now made that would be qualified if existing information were made available.

We need, therefore, first of all, a census of research, and second, a research information service, to be circulated among the states, counties and cities, by which the data may be marshalled, boiled down, and put in useful form; and by which researchers may know what others are doing. For instance, three laboratories were, unknown to each other, investigating the strength of plain concrete under fatigue. Several isolated attempts are being made to design and test experimental concrete roads involving a heavy investment in the aggregate over a half million dollars. Many traffic surveys are planned without a clear idea of the purpose to be served and the significant data to be taken, or the devices for expediting the work. I do not say that it is not well to have several evperimenters working independently in one research, but their efforts would meet with greater success if communication were established.

Thirdly, and most important, the people will be served if the state commissions will recognize research as the Bureau of Public Roads does and give formal status to a research and experiment division attached to the test department and tied up closely with the departments of design, construction and maintenance. My observation is that in the staff of state highway organizations there are men of the research type with the curiosity and the enthusiasm that lead a man to investigate unknown places, but who are now over-burdened with executive duties or tied down to routine work. Research men are not of the type of builders who want action. They are of the student type.

Now, research work that is adequate to solve present day problems cannot be done at odd moments, or by "trouble shooters", or by over-burdened executives with one ear to the telephone and the other to visitors. Research demands some isolation; a man must live in it, and have time for that slow and somewhat unconscious mental process that suddenly crystalizes into clear conceptions of the operation of nature's laws. The researcher must have time for careful planning, for the patient overcoming of experimental difficulties, and for close supervision of the work.

Is it not possible for the states to provide a division of research for field and laboratory research, and for the collecting and analyzing of statistics as an addition to the division of control testing? Is it not a duty? Two states with approximately the same climatic conditions, traffic density, and of nearly the same stage of development, adopt radically different types of construction, which will determine the future well being of highway transport. Decisions should rest upon the laws of engineering and economics. Our 20-billion-dollar highway transport industry must, like any other industry, succeed upon the basis of exact information.

Fourthly, in order that there may be coordinated attack, a map of the field of research should be spread out, similar in aim to the chart drawn by the speaker in the article referred to. In this each worker may find his best field of effort, which is often a local problem. How often have we seen universities seek for a field when material for research is waiting at their doors in the shape of traffic studies and analysis of cost of transport. Professor Dougherty of the University of Tennessee has shown us the value of work right at home.

I would make a plea for a closer union between the state highway organizations and the universities. Call the professors to conference, they will then more intelligently direct the efforts of the students whom later you will employ; and these professors will assist in working out some of your problems.

Plan for Action

I have indicated that the frozen assets of research of the state organizations can be liquidated by the recognition of the research function by the states and by the use of the universities, many of which have experiment stations organized for such service. The Bureau of Public Roads is undoubtedly the most active agency for highway research and the chief vitally interested in this phase of the highway problem; the remarkable achievements of A. J. Goldbeck, in charge of tests and investigations of this bureau, have attracted the attention and admiration of the entire country. Workers are also found in other federal departments, the counties, the cities, and the in-

dustries. In particular, the recently organized research department of the Society of Automotive Engineers under the direction of Dr. Dickinson, is devoted to research in the vehicle as related to the road. Since twelve dollars are spent on the vehicle where one dollar is spent on the road, there is room for research on the vehicle, if we are to cut down the transport bill.

Now, all these agencies which work directly in the field or else on collateral problems, should be coordinated. I do not know of any organization so well designed for this purpose as the Advisory Board of Highway Research of the National Research Council. This Board has been active since August, 1921, and has so far been studying the best plan of action. It works through committees representing the field of economics, operation, design and construction. Messrs. Agg, Mattimore and Goldbeck head three of the committees. The contact of the Advisory Board with the states will best be through the committees of this organization. A committee which will prepare a uniform cost accounting system for maintenance, and collect significant data, will advance the economics of highway transport. It is a matter to be thought out carefully if a useful end is to be served.

If the Advisory Board can unlock the resources of highway research and coordinate our efforts, as I believe it can, functioning as the directing organization, additional financial support must be secured. This support must be from disinterested agencies. As yet the work of the Advisory Board is to be adequately financed.

It is hoped that the state commissioners may find it possible to cooperate with the National Research Council, as the Bureau of Public Roads and the Engineering Foundation are now cooperating, by some form of agreement or contract under which the state may find cooperative funds available and payable to the National Research Council for services in supplying information and directing that research will be to the benefit of the taxpayers of the state.

ROAD SAFETY ESSAY PRIZES OFFERED

To teach the younger generation the necessity of observing care in using the highways, a plan has been launched by the Highway Trnsport Education Committee to induce school children to write essays on the subject and to encourage grammar school teachers to promote such efforts among their pupils. The contest is endorsed by the United States Bureau of Education, and many prizes have been offered by the National Automobile Chamber of Commerce.

For the child writing the best essay on "How I Can Make the Highways More Safe" there is an award of a gold watch and a trip to Wshington, D. C.

Orange County, Florida, expects to use the proceeds of the sale of a $2,250,000 road bond issue for the construction of the Mount Dora and Plymouth Highway, 15 mi. in length, and for the construction of the balance of the county's system—some 50 mi. in all.

MEETINGS

Calendar of Coming Meetings

Jan. 17-19—Iowa Engineering Society.—Thirty-fourth Annual Meeting, Sioux City, Iowa. Secretary, L. A. Canfield, Des Moines, Ia.

Jan. 17-19—Associated General Contractors of America—Third Annual Meeting, Hotel Winton, Cleveland, Ohio. General Manager, R. C. Marshall, Jr., 1038 Munsey Bldg., Washington, D. C.

Jan. 17-20, 1922—American Road Builders' Association.—Nineteenth Annual Convention, Twelfth American Good Roads Congress and Thirteenth Good Roads Show under the auspices of the A. R. B. A., The Coliseum, Chicago, Ill. Secretary, E. L. Powers, 11 Waverly Place, New York, N. Y.

Feb. 12-17—Conference on Highway Engineering.—Eighth Annual Conference, University of Michigan, Ann Arbor, Mich.

The Kansas Engineering Society at its annual meeting on Dec. 22 elected the following officers: president, Lloyd B. Smith; vice-president, P. L. Brockway; secretary-treasurer, J. M. Averill; directors, H. S. Putney and P. J. Ruckel.

The Wisconsin Mineral Aggregate Association elected the following officers at its annual meeting on Dec. 15: president, J. K. Jensen; vice-president, John D. Ort; secretary-treasurer, I. M. Clicquennoi; directors, E. E. Gillen, R. C. Brown, Arthur Blair and L. Laun.

UNIFORM ROAD SIGNS URGED

The Bureau of Public Roads urges the necessity of standardizing direction and warning signs along the highways of every state in the Union. The recommendation is made for the consideration of highway officials, automobile organizations, municipal officials and others interested.

By standardization of all highway danger signs, the department believes automobile accidents may be lessened. Deaths from automobile accidents have nearly doubled since 1915, and the rapid increase of such accidents, it is felt, can be appreciably checked by the adoption of standard danger signs, easily read and distinctive, long American highways.

A tourist at the present time will see almost as many kinds of signs as there are states he visits. Also, in some cases, the style of sign changes in going from one county to another.

A Bill was Recently introduced in Congress providing for the transfer of 1,500 five-ton tractors to the Secretary of Agriculture for distribution to the various states for use in road work.

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

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Volume LXII. January 25, 1922 Number 4

TABLE OF CONTENTS

*The Nineteenth Annual Convention of the American Good Roads Association 49

*The Thirteenth National Good Roads Show . . . 55

Problems of the Highway Contractor. By Henry H. Wilson 60

Cost Keeping on Highway Construction. By A. R. Losh 62

Notes of New York State Road Builders' Association . . 65

Lewis S. Sadler Dies 65

Southwestern International Highway Association Formed 65

EDITORIAL:

The Chicago Convention and Show 59

Operating Exhibits During Sessions 59

MEETINGS:

Calendar 65

University of Kentucky to Hold Highway Conference 65

PERSONAL MENTION 65

*Illustrated

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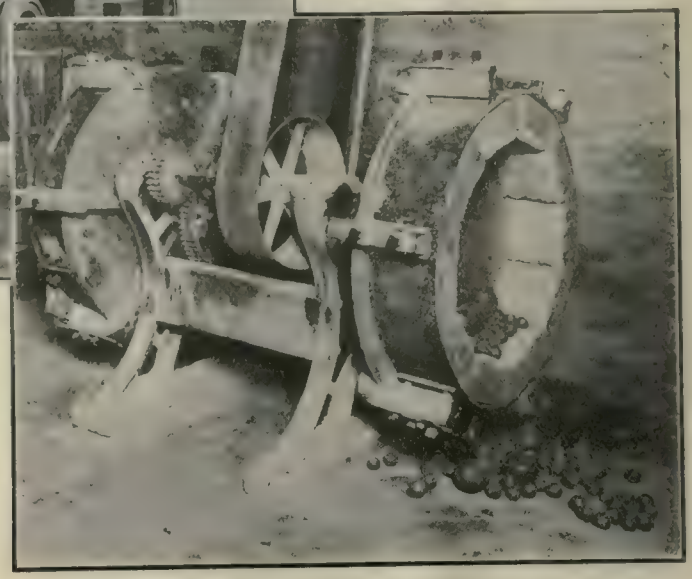
Left: Application of HARD-N-TYTE to Concrete Road



Talbot-Jones rattler, showing test slabs in position

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THIS test was made by the engineers of the General Chemical Company. The specimens used were standard concrete road slabs, 5x5x8 inches, 1-2-3 concrete, made up according to recommendations of Lewis Institute Structural Materials Research Laboratory. Sand and gravel, well graded and of good quality, were used as aggregate. Half of the slabs were treated with Hard-n-tyte in two applications. Treated and untreated samples, 28 days old, were subjected to identical wear in a Talbot-Jones rattler —1800 revolutions and 200 pound charge of iron shot.

Under this test the slabs treated with Hard-n-tyte showed 30% less wear than those not treated. (Note: so severe was this test that more than an inch of concrete was worn from the untreated slabs.)

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CONSTRUCTION TRANSPORTATION MAINTENANCE

WITH WHICH IS INCORPORATED

THE HIGHWAY CONTRACTOR AND ROAD BUILDER

Vol. LXII. NEW YORK, N. Y., JANUARY 25, 1922 Number 4

The Nineteenth Annual Convention of the American Road Builders' Association

Last week the American Road Builders' Association held its Nineteenth Annual Convention and the Thirteenth National Good Roads Show at the Coliseum, Chicago, Ill.

These sessions of the convention were opened Tuesday, Jan. 17th and continued until Friday the 20th, and covered the entire field of highway engineering and its allied administrative, financial and economic phases.

The show was opened in the Coliseum at 8:00 P. M. Jan. 16th and closed at 4:00 P. M. on Jan. 20th. This exhibition was housed in the Coliseum, the Coliseum Gallery, and the Wilson and Greer Buildings, and was not only pronounced the greatest exposition of road building machinery ever assembled in this country, but is believed to have been the greatest collection of machinery of any kind ever brought together at one time in the United States.

In point of numbers the attendance at the convention was well over ten thousand persons. Highway engineers, officials, contractors and others interested in highway development attended the convention, coming from all parts of the United States and Canada. The sessions of the convention were well attended and much interest was shown in the many papers on various highway matters that were presented.

During the entire time the Good Roads Show was open thousands of visitors and delegates were inspecting the exhibits. It is estimated that close to a million dollars worth of road machinery was actually sold by exhibitors,

NINETEENTH ANNUAL DINNER OF THE AMERICAN ROAD BUILDERS' ASSOCIATION, CONGRESS HOTEL, CHICAGO, ILL.

to say nothing of the many inquiries that will subsequently result in sales.

On this and the following pages a chronological report of the proceedings of the convention is given, followed by a list of exhibitors and representatives at the show. It is of particular interest to know that the manufacturers who made exhibits at the show are universally satisfied, declaring that it surpassed all expectations.

Tuesday, January 17th

The convention was formally opened on Tuesday morning with an invocation by the Rev. Joshua Stansfield, Pastor of the McCabe Memorial Church, Chicago, Ill.

After the invocation, President Bowlby announced the appointment of two committees as follows:

Resolutions Committee: C. S. Lee, Highways Information Service, New York City, Chairman; George W. Tillson, Consulting Engineer, LaGrange, Ill.; Frank Page, Chairman, North Carolina State Highway Commission; A. W. Dean, Chief Engineer, Massachusetts Highway Commission; H. G. Shirley, County Engineer, Baltimore County, Maryland; W. A. Welch, Chief Engineer, Palisades Interstate Park Commission, New York City; Frank Terrance, President, Washington State Good Roads Association, Seattle, Wash.

Committee on the Coordination of Dates and Location of Allied National Conventions: C. M. Upham, Chairman, Chief Enginer, North Carolina State Highway Department, representing the American Road Builders' Association and the American Association of State Highway Officials; W. D. Uhler, Chief Engineer, Pennsylvania State Highway Department, representing the American Road Builders' Association and the American Society of Civil Engineers; R. C. Marshall, Washington, D. C., representing the Associated General Contractors of America and the American Society of Civil Engineers. This committee will endeavor to have the three national associations represented take the necessary steps to hold their annual conventions in the same city on the same dates.

The address of welcome on behalf of the City of Chicago was delivered by Albert Veeders, Assistant Corporation Counsel of the City of Chicago. Frank Terrance, President of the Washington State Good Roads Association, responded for the association.

The following communications were then read by President Bowlby:

Colonel H. L. Bowlby.
President American Road Builders' Association.
My dear Colonel Bowlby:

It is with profound regret that I must decline the kind invitation of the American Road Builders' Association to attend and address their Nineteenth Annual Convention to be held at Chicago beginning January 17th next. However, your delegates will agree with me that the present industrial situation in this country merits the closest possible attention by Congress, and while it was originally my purpose to be present not only on the opening day, but throughout the entire convention, I have now found that extreme pressure of official business—especially in connection with my duties on the Senate Appropriations Committee—prevents my leaving Washington even for a day or two.

In the matter of sane and comprehensive highway construction, our interests and wishes are identical. I trust and believe that this convention will serve to form throughout the country an even better understanding of this important question, and to encourage our present good roads program.

Mention will no doubt be made of the highway bill which became a law last November. I am proud that my name is connected with this measure, although in all fairness tribute must be paid to Senator Charles E. Townsend of Michigan, one of the most stalwart champions of good roads for many years, and who as Chairman of the Committee on Post Offices and Post Roads had much to do toward bringing this matter to a successful conclusion. His support and influence can hardly be measured.

The bill, as you know, was originally intended to remedy the inequality existing between the public-land States of the west and other sections of the country, an inequality caused by the presence in western States of large tracts of unappropriated Federal lands on which no taxes were paid, and yet which had to be traversed by substantial highways. The Phipps-Townsend bill, as it is commonly called, provided that in such public-land States the percentage of contribution required on the part of the State should be decreased in the proportion which the amount of public land within its borders bore to the total area of the State. This proposal was so eminently fair that, although it only affected ten States of the Union, it received general support in Congress. Of course, the allotments made to other States would not thereby decrease, as this only rendered available to western State's funds set aside for their use which could not otherwise be secured.

I have only touched upon one feature of this important measure. Other liberalizing amendments to the present law were made, including the provision that States should have two years instead of one in which to claim their portion of the general fund.

The appropriation made is significant. In times of stress Government expenditures are ordinarily cut to the bone, and to that doctrine I subscribe; but in the case of highway construction $75,000,000 was appropriated for use during the present fiscal year, $5,000,000 additional for the construction of roads in national forests this year, and $10,000,000 for similar purposes during the following year. The reason for these appropriations is not hard to find. Our legislators realized that to stop proper highway construction is not economy at all, but on the contrary one of the worst forms of extravagance.

The Congress felt that States should be encouraged in the program which had been installed and that a cessation of good road construction at a time when so much should be done along such lines would be indeed unfortunate. Personally, I would like to have seen the amount fixed at $100,000,000, as at first provided, instead of $75,000,000; but in any event the large appropriation made speaks for itself

It was my pleasure to witness the signing of this highway act. As President Harding affixed his signature to the bill, it occurred to me that here was one measure concerning which there was no question, one legislative proposition which could not be called in any sense an experiment but which represented a forward step along sane and constructive lines.

There should be no difference of opinion as to the vital principles involved; there should be no sectionalism, no feeling of class discrimination; for, as a matter of fact, good roads inure to the benefit of all our people—the farmer, the manufacturer, the local merchant and incidentally the tourist.

Conventions such as the present one tend to promote proper co-operation in all parts of the country, and I believe that acting as a unit the people of the United States will establish at an early date a system of good roads second to none in the world.

With all good wishes for the success of your convention,

Yours sincerely,

(Signed) LAWRENCE C. PHIPPS

January 10, 1922.

Colonel H. L. Bowlby,
President American Road Builders' Association.
My dear Colonel Bowlby:

I learn that you are to attend the Annual Meeting of the American Road Builders' Association in Chicago next week, and am taking advantage of that fact to ask you to extend my greetings and good wishes to the gathering.

There is now pretty nearly universal agreement that no single public improvement has done in recent years or will do in the coming years, more for the general good of the country, than the development of our highway system. The task is an enormous one, but better methods both in physical construction and in the relations of the community to highway development have been taking form in a most encouraging way. Your own organization has been a chief contributor

in this direction, and it is with much pleasure that I ask you to extend to its members my best wishes for their con' tinued success.

Very sincerely,
(Signed) WARREN G. HARDING.

Following the reading of the above communications, President Bowlby gave a short address reviewing the history of the association and pointing out the relation of road development to national unity.

"Good transportation facilities constitute one of the greatest sources of a nation's wealth," said President Bowlby. "We of this generation do not have to search the pages of history to appreciate the vital part that highways have played in our national development. The passenger automobile and the motor truck industries which, combined, now rank third in America, both in capital invested and in value of output, are absolutely dependent for their stability and growth upon good roads. The expansion of agricultural production is largely a question of good roads. This is true also of every phase of our industrial development. The highways are the arteries of trade and through them flows the blood which gives to the nation its commercial life. It is these arteries that band the communities together, foster the greater community spirit, develop the national unity and weld the American people into a cohesive whole. And it is only by nationalism such as this that America, the greatest of all republics and the nation that now enjoys the leadership of the world, can hope to fulfill that great mission of equality, fraternity and eternal brotherhood toward which the finger of destiny points the way."

The afternoon session was presided over by J. H. Mullen, Chief Engineer of the Minnesota State Highway Department. This session was devoted to the consideration of bituminous types of pavements.

The firs tpaper, "Bituminous Pavements for Street and Road Pavements," was presented by Hugh W. Skidmore, of the Chicago Paving Laboratory, Chicago, Ill.

W. A. Welch, Chief Engineer of the Palisades Interstate Park Commission, New York, N. Y., next presented a paper, "Utilization of Local Materials for Mineral Aggregate in Bituminous Macadam Roads." Mr. Welch said that "the proper use of local mineral aggregate in bituminous road construction means great economy in these days of high transportation and labor costs. It would be wiser for the engineer to carefully study all available local mineral aggregate and prepare his specifications to permit the greatest possible use of it in his surfaces, than to fall into the easier method of copying standard specifications and so compelling contractors to import these aggregates and so greatly increase costs."

The next paper, "Asphalt Specifications—Past, Present and Future," was presented by Leroy W. Law, Chief Chemist of the New Orleans Refining Co., Inc., New Orleans, La. Mr. Law reviewed the development of present asphalt specifications and pointed out that the consistency or penetration limits in present specifications were too narrow.

Roy M. Green, of the Western Laboratories, Lincoln, Neb., presented a paper on "Standardized Specifications for Mineral Aggregates for Asphalt Pavements." Mr. Green emphasized that standard specifications can not be drawn up to apply to all sections of the country and discussed the specifications required in various types of asphaltic pavements.

In the evening the association gave a smoker in the convention hall at the Coliseum for delegates and visitors. This was followed by moving pictures.

Wednesday, January 18th

C. M. Upham, Chief Engineer of the North Carolina State Highway Department, presided at the morning session. The first paper was presented by Thomas H. MacDonald, Chief, U. S. Bureau of Public Roads, on "The Highway Outlook."

"During the period 1910-1921," pointed out Mr. MacDonald "the potential number of motor vehicles demanding highway service increased more than 1,800 per cent and our actual expenditures for road construction and maintenance increased about 400 per cent. During the period 1910-1914, motor vehicles increased more than 1,100 per cent and highway expenditures about 140 per cent. During the period 1914-1921, motor vehicles increased about 700 per cent and highway expenditures about 260 per cent."

Jay Downer, Chief Engineer of the Bronx Parkway Commission, New York, N. Y., read his paper, "Utilizing Small Stream Valleys for Traffice Routes." Mr. Downer spoke of the work of constructing a 15-mi. road along the Bronx River in the Bronx River Parkway Reservation, New York City, illustrating his paper by lantern slides.

The next paper, "Cooperation in Road Building," was presented by William Ord, Manager of the Paving Department of the Lakewood Engineering Company, Cleveland, O.

D. C. Fenner, Manager of the Public Works Department of the International Motor Co., New York, N. Y., presented a paper on "Uniform Legislation as Affecting Highway Traffic and Highway Transport."

At the afternoon session M. O. Eldridge, Chairman of the Roads Board of the American Automobile Association, presided.

The first paper, "Highway Finance," was presented by Arthur H. Blanchard, Professor of Highway Engineering and Highway Transport, University of Michigan.

C. M. Babcock, State Highway Commissioner of Minnesota, next presented a paper on "The Minnesota Experience in Highway Financing."

The next paper, "The Proposed Wisconsin Plan of Highway Finance," was presented by A. R. Hirst, State Highway Commissioner of Wisconsin.

C. M. Upham, Chief Engineer of the North Carolina State Highway Department, presented a paper on "The Business of a Highway Commission," saying in part:

"The business of a highway commission is to act as an agent for the tax payers, for the best economic purchase of roads that can be maintained at a minimum cost,

and at the same time, furnish to the taxpayers satisfactory means of transportation, whereby traffic may operate at a minimum of expense.

"In addition to securing all the engineering facts, the commission should make no purchases of roads before it has acquainted itself with the condition of the financial market, taking advantage if possible, of the proper market in the disposal of its bonds, or for buying its materials or roads on a low market. By studying the situation and purchasing and contracting on a favorable market, will mean the saving of large amounts of money for the taxpayers.' '

The paper of Prevost Hubbard, Chemical Engineer of the Asphalt Association, New York, N. Y., on the "Selection and Proportioning of Sands for Sheet Asphalt Paving Mixtures," was read by Mr. Rosengarten because of the illness of Mr. Hubbard. Stereopticon views were shown to illustrate the paper.

A paper on the "Use of Brick for Street and Road Surfaces" was presented by W. W. Horner, Chief Engineer, Sewers and Paving, St. Louis, Mo. Mr. Horner discussed the relative advantages of lug and lugless paving brick and reviewed the work of the recent conference on paving brick at which the number of varieties of paving brick was reduced from 66 to 11.

At 6 P. M. the president's dinner to the past presidents and directors of the Association was given at the Congress Hotel. The principal speaker was F. C. Biggs, Minister of Public Works of the Province of Ontario, Canada, who said in part:

"We have 57,000 mi. of road all told in Ontario. We propose to spend $25,000,000 on new roads this year. We have 2,000 mi. of improved roads now under maintenance. The Dominion Government pays 40% of the maintenance; the Province of Ontario 40% and the municipalities 20%. In municipalities with less than 750 population, our roads are built through the municipality without cost to the town. If the town is above 750 in population, the Province pays 40% of the central 20-ft. width.

"Politics is not known in road construction in Ontario. We have no commission to blame for anything. The Minister of Public Works is responsible to the people from the floor of parliament. Our people are not favorable to commissions. If the Minister of Public Works does not make good, he finds after the next election that somebody else has his job.

"All of the bridge construction in Ontario of whatever nature, whether the bridge be 10-ft. long or 1,000-ft. long, is done by my department. We have a staff of 65 engineers all of whom are directly responsible to the head of the department. Of this staff 97% served with the Canadian forces in Flanders or France. We are rather proud of our part in that."

At 8 P. M. the exhibitors gave a smoker and entertainment for delegates and members in the convention hall at the Coliseum. Popular songs were sung and several dancers entertained the guests, after which coffee and sandwiches were served.

Thursday, January 19th

A. R. Hirst, State Highway Engineer of Wisconsin, presided at the morning session, which was devoted to the consideration of concrete roads.

The first paper, "The Selection of the Mineral Aggregates for Concrete Roads," was presented by Duff A. Abrams, Director, Structural Materials Research Laboratory, Lewis Institute, Chicago, Ill. This paper will be published in a subsequent issue of GOOD ROADS.

R. W. Crum, State Testing Engineer of Iowa, who was scheduled to present a paper on "Inspection and Control of Materials for Concrete Roads," was unavoidably detained and did not present his paper.

The second paper, on the "Importance of Surface Finish and Methods of Control," was presented by H. E. Breed, Consulting Engineer, New York, N. Y. Mr. Breed mentioned five causes of unevenness in pavement surfaces, viz., foreign materials in the aggregate which fail to amalgamate and are ousted, leaving holes and depressions; non-uniform aggregate; poor workmanship in striking off and finishing; cracks due to frost and other causes; uneven joints. In the discussion which followed J. A. Griffith, City Engineer of Los Angeles, Cal., advanced the opinion that the proper rolling of the subgrade tended to greatly lengthen the life of the surface finish.

A paper on "Single Track Concrete Roads for the Average County," was next presented by P. C. McArdle, former County Highway Superintendent of Vermillion County, Illinois. Mr. McArdle said that "single track concrete roads are the best for the average county to build at the present, and when finances and conditions permit they can be most easily widened to double track roads," saying that Vermillion County during the past five years had built 210 mi. of single track concrete roads. In the discussion which followed practically every speaker took exception to Mr. McArdle's paper, the consensus of opinion favoring the reducing of mileage if necessary to build two track roads.

The last paper to be presented at the morning session was "Paving Widths for Highways Serving Large Cities," by William F. Cavanaugh, County Highway Engineer of Milwaukee County, Wisconsin.

At the afternoon session A. W. Dean, Chief Engineer of the Division of Highways, Massachusetts Department of Public Works, presided. The first paper, on "Truck Overloading, Its Relation to Road Construction and Maintenance," was presented by J. G. McKay, Professor of Economics, University of Wisconsin.

The second paper was presented by Clifford Older, Chief Highway Engineer of Illinois, on "The Illinois Experimental Road," and was illustrated by various charts. As a result of the experiments conducted by Illinois, Mr. Older estimates that approximately $1,500 per mile is saved on roads now being constructed.

A paper on "Highway Research" was next presented

by W. K. Hatt, Director of the Advisory Board on Highway Research of the National Research Council, in which he outlined the work of the Advisory Board on Highway Research.

The last paper presented on Thursday afternoon was "Highway Researches and What the Results Indicate," by A. T. Goldbeck, Chief, Division of Tests, U. S. Bureau of Public Roads.

Friday, January 20th

The first paper presented at the morning session of the last day was on "A Systematic Study of Gravels for Road Purposes," by Wallace F. Purrington, Chemist and Testing Engineer, New Hampshire State Highway Department. Mr. Purrington reviewed the work carried on by the New Hampshire State Highway Department in making a survey of gravels in the state and formulating specifications for road building gravels.

A. R. Losh, Assistant Chief of Construction, U. S. Bureau of Public Roads, next presented a paper on "Cost Keeping on Highway Construction," pointing out that with the unstabilized conditions of labor and materials now prevailing in the highway field, the necessity of accurate cost accounting of road construction is greater than ever before.

The paper of H. H. Wilson, of Winston & Co., New York City, on "The Highway Contractor's Problems," was read by Charles T. Puff, Secretary of the Pennsylvania Associated Highway Contractors' Association, Mr. Wilson being detained at the convention of the Associated General Contractors' Association, which was being held at Cleveland, O.

H. L. Bowlby, President of the Association, presided at the business session held in the afternoon. A number of important resolutions were adopted, as follows:

Resolutions

WHEREAS, It has come to the attention of this Association that "Public Roads," the monthly magazine of the Bureau of Public Roads has been indefinitely suspended together with other government periodicals, and

WHEREAS, "Public Roads" is a necessary medium to dis seminate the results of highway research and for the interchange of opinions and ideas between the U. S. Bureau of Public Roads and the Highway departments of the several states in connection with the administratin of cooperative highway construction under the Federal Highway Act.

NOW, THEREFORE, BE IT RESOLVED, That the American Road Builders' Association endorses "Public Roads" as heretofore issued, and urges that its publication be immediately resumed.

WHEREAS, Advertising signs upon, along or adjacent to public highways serve no good purpose, but, on the contrary, are a public nuisance in that they destroy the beauty of our landscapes, impair vision in dangerous places, and add to the difficulty of properly guiding and warning traffic,

BE IT, THEREFORE, RESOLVED, That the American Road Builders' Association pledges its support to any proper movement to eliminate such advertising signs and urges upon its individual members the importance of aiding and encouraging legislation in all states to effect said elimination, to the end that our highways may be fully and safely occupied and enjoyed by the public, for the use of whom they are acquired and built.

WHEREAS, Grade crossings of railroad and interurban lines with our highways constitute a grave menace to human life and property, and

WHEREAS, The increasing travel on our highways is each year making the danger greater and the list of dead and injured longer,

BE IT, THEREFORE, RESOLVED, That the American Road Builders' Association pledges itself collectively and as individuals to use its best efforts to speed up the properly planned elimination of grade crossings, to the end that all of them, especially on the main traveled highways, shall be eliminated as rapidly as funds can be made available by the public and the railway companies.

BE IT FURTHER RESOLVED, That we condemn, as against public policy, the present attitude of negation adopted by too many railroad companies and by too many state railroad commissions, because such attitude has resulted in the slackening of elimination work at a time when the protection of the traveling public is much more urgent than ever before.

BE IT RESOLVED, That the American Road Builders' Association heartily endorses the action of Congress in adopting a policy of federal aid for highways to be applied to a definite system of highways as provided in the Federal Highway Act which went into effect November 9, 1921.

We pledge our hearty and unqualified support to the Federal Bureau of Public Roads in carrying out the provisions of said act.

Inasmuch as the act contemplates continued federal participation with the states in highway improvement, we realize and emphasize the absolute necessity of a definite policy projected far enough into the future to make possible the economic and satisfactory planning and carrying out of the intent and purpose of the act.

To this end we endorse H. R. 8978, introduced by the Hon. Roy Woodruff, which bill authorizes the appropriation of $100,000,000 annually for five years beginning July 1, 1922, as a general federal aid appropriation, and we also urge that adequate provision be made in the said bill for the continued development of highways in and adjacent to the National Parks, forest areas and Indian reservations and the Territory of Alaska **under unified control.**

The adoption of this five-year program is necessary to enable the states, through their legislatures, to make proper provisions for the requisite state cooperation in this enterprise.

WHEREAS, There are many inequalities existing in the present freight rates on road materials, and

WHEREAS, The highway work of the states and the Federal Government should not be required to pay more than its fair share of the cost of keeping up our system of railroad transportation,

BE IT, THEREFORE, RESOLVED, That the American Road Builders' Association urges upon the Interstate Commerce Commission and upon the various state railroad commissions (or equivalent state bodies) the importance of a review and comparison of the present rates on road materials and on other commodities, to the end that present existing inequalities may be removed and the taxpayers' interests protected.

WHEREAS, By far the greater portion of the cost of modern highway construction and maintenance is due to the necessity of providing adequately for the movement of motor vehicles, and

WHEREAS, there is a lack of uniformity in the motor vehicle registration and taxation laws of the various States from which a substantial portion of the state road revenues are now derived, and

WHEREAS, These taxes do not distribute the cost equitably over the vehicle in proportion to its use of the highway, now, therefore,

BE IT RESOLVED, By the American Road Builders' Association that we urge upon all States the fairness and necessity of collecting an adequate portion of highway financing from the users of motor vehicles, and

BE IT FURTHER RESOLVED, That we favor a gasoline tax in lieu of all other taxes on motor vehicles plus a just and equitable tax on commercial vehicles based on the service rendered by the highways, and

BE IT FURTHER RESOLVED, That the receipts from the gasoline or other motor vehicle taxes be reserved solely for road improvement, under the supervision of the State highway departments, and

BE IT FURTHER RESOLVED, That we appeal to the motorist for his support of this policy.

BE IT RESOLVED, That the American Road Buildres' Association welcomes the establishment by the National Research Council of the Advisory Board on Highway Research and that the Association pledges its support to the Advisory Board in this much needed effort to stimulate and coordinate highway research.

WHEREAS, The American people have embarked upon programs of highway improvement involving the expenditure of many billions of dollars in the next decade, and

WHEREAS, The effective expenditure of these billions of dollars, and the proper carrying out of these programs, depend upon the ability and efficiency of the federal and state highway departments, and

WHEREAS, The American people have not so far appreciated the magnitude of this enterprise or the necessity of permanent and efficient organizations to carry it on,

BE IT, THEREFORE, RESOLVED, That this organization pledge itself to work for efficiency and permanency in the personnel of all departments engaged in this enterprise, for the elimination of partisan politics from the operation, and for the reward of ability wherever found.

WHEREAS, It is the experience of road engineers that eighteen foot pavement widths carrying dense traffic in the vicinity of large cities are not adequate,

THEREFIRE, BE IT RESOLVED, That the American Road Builders' Association go on record as favoring a pavement width of not less than twenty feet for all trunk highways or roads carrying dense traffic.

BE IT RESOLVED, That this convention does hereby tender to its President, Col. H. L. Bowlby, its best and sincerest thanks and appreciation for the courtesies extended and efforts in making this convention the greatest and best ever held by the Association, and

That a suitably worded and properly engraved testimonial setting forth these facts be prepared and presented to him by this Association.

WHEREAS, The Thirteenth National Good Roads Show has been universally recognized as the greatest success ever attempted by this Association, and

WHEREAS, Its interest was greatly increased by the elaborate and complete exhibit furnished by the United States Bureau of Public Roads, therefore,

BE IT RESOLVED, By the American Road Builders' Association in convention assembled in Chicago in January, 1922, that this association express its sincere thanks to the Bureau and that suitable testimony be sent to its Chief, Mr. Thomas H. MacDonald, expressing the appreciation of the association for the efforts of the Bureau in helping to make this show the most complete and instructive of its kind ever held.

BE IT RESOLVED, By the American Road Builders' Association in convention assembled, that the efforts by the various committees that are now working to solve the problem of finding a method of stabilizing subgrades and completing the study of the relationship of subgrade to traffic and road surfaces should have the hearty support of this association, and that every assistance be rendered from whatever source to speedily assist in solving this problem.

RESOLVED, That the American Road Builders' Association, assembled in Chicago at its 19th annual convention, petition the President to take such steps as may be necessary for the Government of the United States of America to become a member of the International Road Congress.

Following the reading and adoption of the resolutions, a nominating committee was elected consisting of R. A. Meeker, Right of Way Engineer, New Jersey State Highway Department; W. D. Uhler, Chief Engineer, Pennsylvania State Highway Department; I. W. Patterson, Chief Engineer, Rhode Island State Board of Public Roads; Fred W. Sarr, First Deputy State Highway Commissioner of New York, and W. G. Sucro, Development & Construction Co., Baltimore, Md.

MARYLAND MARKS ROADS WELL

The Maryland State Highway Department has recently adopted a system of direction and distance signs at road intersections which places it far ahead of many states in the clear designation of roads for the benefit of travelers.

The signs are faced with metal and set on wooden posts into concrete bases. They show the name of the highway in white letters on a black background, the distance to and from important points and all principal connections. In addition, 10x10 ft. maps are being erected at the limits of each town. They show the main routes through the town in white and the secondary routes in gray; the names of streets and well established landmarks are all marked so that the traveler can choose his itinerary according to the points of interest. They are oriented to read in the direction of travel, so that if the signboard were laid on the ground the routes follow the proper directions. On each map is a red star with the words "You are now at this point."

At the top of mountain grades similar signboards are being erected to tell the motorists the number of miles down the mountain, warn him of curves and give him concise instructions about how to drive in order to avoid accident. At all entrances to the State signs carrying the salient points of the Maryland vehicle laws are going to inform the visitor about speed limits and traffic rules. The entire signboard system is under contract for repair and renewal each year.

Concrete Pavement Laid in 1922 totaled 62,000,000 sq. yd., or 6,000 mi. of 18-foot road, according to a recent statement of the Portland Cement Association.

The Thirteenth National Good Roads Show

The Thirteenth National Good Roads Show of the American Road Builders' Association at the Coliseum, Chicago, Ill., Jan. 16-20, was the most successful show ever held by the Association, with 177 manufacturers of road machinery and materials having exhibits. A list of the names of exhibitors is given below with the names of the representatives and their comments on the show. A more complete list of exhibitors and the nature of exhibits was given in the January 11th issue of GOOD ROADS.

Acme Road Machinery Co., Frankfort, N. Y. G. Pearson and L. G. Jennings. "Greatest of all shows like it and bound to be beneficial to good road building."

J. D. Adams & Co., Indianapolis, Ind. J. T. Trumbull. "Wonderful success—many orders and prospects."

Allis Chalmers Manufacturing Co., Milwaukee, Wis. Mr. Brewsangh, Adv. Mgr. "Splendid outlook for future."

American Gas Accumulator Co., Elizabeth, N. J. W. R. Townsend. "Splendid exhibit and will bring wonderful returns."

American Production & Trading Co., Chicago, Ill. T. E. Morrison and Mr. Kelsey. "Show results warrant our getting larger space for next year."

American Refractories Co., Devil's Lake, Wis. E. J. Winkelman. "Wonderful prospects which could be had no other way."

American Tar Products Co., Chicago, Ill. P. T. Griffiths. "Outlook after this show is very favorable to increased business."

Anthony Co., Inc., Streator, Ill. T. C. Eads.

Asphalt Pavement Retreading Co., Chicago, Ill. G. H. Lutz, Vice-Pres. and F. H. Flory, Pres. "Show makes the business outlook fine."

Austin Machine Corporation, Chicago, Ill. G. Stewart, Adv. Mgr. "Great exhibit and of big sales value."

Austin Western Road Machinery Co., Chicago, Ill. H. F. Barrows, Adv. Mgr. "Well pleased with results—wonderful show."

Automotive Utilities Corporation, Detroit, Mich. Mr. Thomas. "Splendid show, glad to take part in it."

Avery Co., Peoria, Ill. J. H. Wiley, Adv. Mgr. "Show has given us great prospects—will get more space next year."

Ball Engine Co., Erie, Pa. J. A. Garber. "Received many orders directly through show."

Barber Asphalt Paving Co., Philadelphia, Pa. R. G. McKay, Dist. Mgr. "Very excellent show—have our share of the business now."

Barber Green Co., Aurora, Ill. G. H. Nickel. "We have sure done some real business at this show."

The Barrett Co., New York City. G. E. Martin and B. H. McGinnity. "Show is a splendid advertisement."

Beach Manufacturing Co., Charlotte, Mich. F. H. Beach and J. W. Sanders. "Splendid outlook for new business."

Blaw-Knox Co., Pittsburgh, Pa. T. M. Ornitz. "Good show and good returns."

Brown Hoisting Machinery Co., Cleveland, O. J. P. Case and C. C. Dancer. "Great show, has given us many real prospects."

Bucyrus Co., South Milwaukee, Wis. M. J. Woodhull. "Splendid show."

The Buda Co., Harvey, Ill. W. J. Dukes. Very well pleased with results of show."

Buff & Buff Manufacturing Co., Chicago, Ill. M. S. Jordan and R. M. Myers. "Far better show than last year from every angle."

Burch Plow Works, Crestline, O. B. H. Ferguson. "I am a booster for the show. Everything fine, very well satisfied with results."

Carbic Manufacturing Co., Chicago, Ill. A. D. Guthrie, Dist. Mgr. "Showing of interest makes us very optimistic regarding future business."

The Philip Carey Co., Lockland, Cincinnati, O. Mr. Koester. "We are very well satisfied with returns."

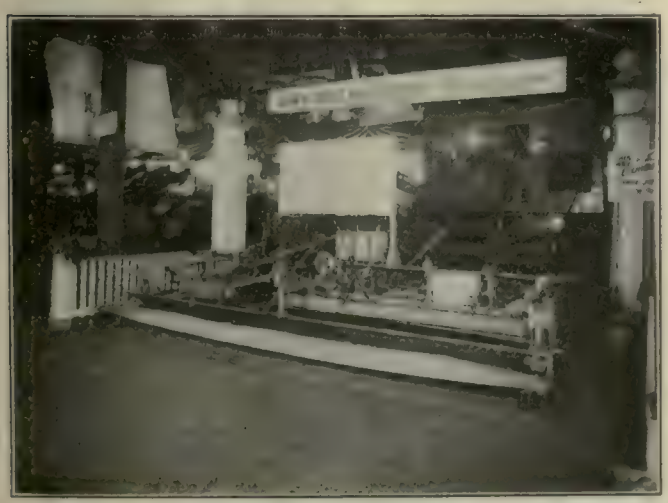
Chain Belt Co., Milwaukee, Wis., B. F. Devine. "Very much pleased with the show in every respect."

Clark Tructractor Co., Buchanan, Mich. L. J. Schneider. "Show has certainly given us our share of the business."

Climax Engineering Co., Clinton, Ia. C. B. Stebbins. "Very satisfactory returns from show."

Concrete Steel Form Co., New York and Chicago, Ill. W. S. Edge, Chief Engr. "Best show of its kind."

Conneaut Shovel Co., Conneaut, O. C. J. Welsh. "Very good show—prospects for future business are immense."



GROUPS OF EXHIBITS AT THE THIRTEENTH NATIONAL GOOD ROADS SHOW

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R. F. Conway Co., Chicago, Ill. W. Damewood. "Show has given us very satisfactory results."

Cook Motors Corporation, Kankakee, Ill. C. M. Wilson. "Great many real live prospects from show."

Domestic Engineering & Pump Co., Shippensburg, Pa. W. E. Barbour, Sales Mgr. and C. B. Segner, Vice-Pres. "Good show with better results than last year."

Dunn Road Machine Co. Conneaut, O. J. M. Rathmell. "Absolutely satisfied in every respect with the show."

East Iron & Machine Co., Lima, O. C. C. Mosher and G. Merriman. "Show has proved a great investment to us."

Easton Car & Construction Co., Easton, Pa. A. R. Amos and J. M. Latimer. "Splendid show and many prospective buyers."

Electrical & Specialty Supply Co., Chicago, Ill. Donn C. Mitchell, Sales Manager, and L. W. McOmber, General Manager. "Pleased with results and amply repaid."

Elgin Sales Corporation, Chicago, Ill. G. O. Dodge and A. M. Anderson. "From the standpoint of future business alone, this is a wonderfully successful show."

Erie Steel Construction Co., Erie, Pa. E. F. Jones and C. H. Fry.

Fate Root Heath Co., Plymouth, O. H. R. Sykes and W. O. Ritter. "Most beneficial show from any angle."

Field Body Corporation, Chicago, Ill. A. W. Hempel. "Fine show many prospective buyers."

Foote Concrete Machine Co., Chicago, Ill. Mr. Wilcox. "Fine show—gives favorable business impression to all."

Four Wheel Drive Auto Co., Clintonville, Wis. C. J. Cassese. "Show giving splendid prospects—we are satisfied."

Fox Rotary Snow Broom, Newark, N. J. Mr. Von Keller. "Splendid show and many sales."

Galion Iron Works & Manufacturing Co., Galion, O. "This show elevates the road building industry."

General Motors Truck Co., Pontiac, Mich. E. J. Kilburn. "Fine show—giving splendid prospects."

Good Roads Machine Co., Chicago, Ill. C. C. Stockman. "Good show and a great advertisement."

W. & L. E. Gurley, Troy, N. Y. C. H. Smart. "Indications of returns are very favorable."

Hadfield Penfield Steel Co., Bucyrus, O. R. O. Perrott, Res. Mgr. "First showing—very successful—good advertising."

Handy Sack Baler Co., Cedar Rapids, Ia. O. G. Mendt, Pres. and C. A. Weber, Treas. "Biggest showing we ever had."

Hastings Pavement Co. New York City. F. Rogers. "Splendid show—expect good returns."

The Heil Co., Milwaukee, Wis. J. P. Heil, Vice-Pres. and E. C. Gilmore, Sales Mgr. "Show will cause a big boom in the road building game and help business in general."

Heltzel Steelform & Iron Co., Warren, Ia. W. J. Savage, Mgr. "Best show we have ever been in."

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Highland Body Manufacturing Co., Chicago, Ill. W. Morrison, Pres. and P. H. Willis, Res. Mgr. "Best show of its kind."

Highway Hoist & Body Co., Edgerton, Wis. Mr. Menhall, Pres. "Most of our inquiries have resulted in purchases."

Holt Manufacturing Co., Peoria, Ill. Nick Hall. "Extremely well pleased and I am hard to please."

Hough Mechanical Hoist Co., Chicago, Ill. E. B. Hough, Pres., F. L. Peck, Treas., T. T. Peck, Sec. "This show will give a great impetus to the good roads movement throughout the country."

The Hug Lumber & Construction Co., Highland, Ill. C. J. Hug, Pres. "Fine show—gives great prospects."

Charles Hvass & Co., New York City. B. C. Hvass and C. T. Hvass. "Splendid show—we are favorably impressed with the returns."

Indiana Truck Corporation, Marion, Ind. H. K. York. "Dandy show from every standpoint."

International Motor Co., New York City. Mr. Fenner. "Very satisfactory returns—expect us at the next show."

International Steel Tie Co., Cleveland, O. T. J. Lavin. "Results of road congress and show will be of great benefit to the good roads program in all states."

Jennings Automatic Dump Body Co., Roanoke, Va., Z. V. White. "World's greatest road show."

Paul J. Kalman, Inc., Chicago, Ill. Mr. Pederson. "Show will increase the trend of road material business."

Kentucky Rock Asphalt Co., Louisville, Ky. J. C. Kelly. "Show has brought many prospects."

Kinney Manufacturing Co., Boston, Mass. A. J. Munday and W. Worcester. "Have gained many prospective buyers."

Kissel Motor Car Co., Hartford, Wis. G. B. Davey. "Enough to say that the show is simply great and results will be."

Koehring Co., Milwaukee, Wis. Capt. K. Talbot. "Absolutely solid for this show—great success."

Koppel Industrial Car & Equipment Co., Koppel, Pa. Mr. Prausnitz. "Best show ever—fine sales prospects."

Lakewood Engineering Co., Cleveland, O. W. Ord, Mgr. "Best show ever seen—bound to have great results."

Larco Wrench Co., Chicago, Ill. S. M. Shackleford. "Very good show and many orders taken."

Lee Trailer & Body Co., Chicago, Ill. Mr. Howard. "This show has given us splendid sales."

LeRoi Co., Milwaukee, Wis. W. R. Karl and Odin Hagen. "More than satisfied with returns."

Littleford Bros., Cincinnati, O. H. Streatman. "Dandy show and has given us pleasure and profit."

Malis Power & Supply Co., Chicago, Ill. M. M. Malis and H. Baron. "Sold completely out of everything and have orders far into the future."

The Maxon Co., Milwaukee, Wis. G. Maxon, Jr. "It's a wonderful show."

Metal Forms Corporation, Milwaukee, Wis. R. M. Moss and O. B. Pulis. "A most wonderful success—organization is to be greatly complimented."

Morand Cushion Wheel Co., Chicago, Ill. I. E. Hawkins. "Many people really interested in show—business outlook very good."

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National Steel Fabrics Co., Pittsburgh, Pa. E. L. Benedict, Sales Mgr. "After seeing this show, business outlook is very optimistic."

Oliver Chilled Plows, South Bend, Mich. C. J. Sellers. "Wonderful results from the sales angle."

Oshkosh Manufacturing Co., Oshkosh, Wis. R. D. Houghton. "Wonderful show and great prospects."

Parker Motor Truck Co., Milwaukee, Wis. J. Tracy and B. H. James. "Great show and successful from every viewpoint."

Pawling & Harnishfeger Co., Milwaukee, Wis. R. A. S. Johnson. "The show is surely a winner and we will have more space next year."

The Pioneer Asphalt Co., Laurenceville, Ill. J. K. Riley and I. T. Sanborn. "A wonderful show with mighty results."

Portland Cement Co., Chicago, Ill. G. S. Eaton and D. A. Holmes. "Splendid show and bound to do a great deal of good for the cause."

Reo Motor Car Co., Lansing, Mich. Mr. Sutherland and S. H. Block. We are very well pleased with results."

Republic Truck Sales Corporatoin, Alma, Mich. H. L. Dewey. "Greatly pleased with results—many prospects."

Robertson Bros. Manufacturing Co., Chicago, Ill. W. C. Burrell and W. F. Abbott. "Mighty good exhibit and a wonderful trade stimulator."

Rogers Tractor Co., Albion, Pa. C. A. Rogers, Pres. Splendid show and glad to take part in it."

Safety Mushroom Light Co., Milwaukee, Wis. F. S. Laurie. "An unusually large number of inquiries."

Sasgen Derrick Co., Chicago, Ill., M. T. Sasgen, Mgr. "Show is a very great success."

Sauerman Bros. Chicago, Ill. D. D. Gilfoyle and J. A. Sauerman. "Well satisfied with results—show has attendance of the best buyers."

Sewell Cushion Wheel Co. Detroit, Mich. Mr. Storm. "Our exhibit is a great success—we'll be here next year."

Shaw-Enders Tractor Co., Minneapolis, Minn.—C. D. Einochs. "Show is satisfactory from every angle."

Shunk Manufacturing Co., Bucyrus, O. J. L. Smith. "Great show and many orders as a result."

T. L. Smith Co., Milwaukee, Wis. Mr. Bowen. "Fine show and good prospects."

Smith Engineering Co., Milwaukee, Wis. D. D. Barnes. "Great show giving wonderful prospects."

Standard Oil Co., Chicago, Ill. W. H. Myers and H. C. Ellis. "We really appreciate what this exhibit means to the cause of good roads—excellent show and will bring results."

Stoughton Wagon Co., Stoughton, Wis. O. J. Noer. "Mighty good show and many prospective buyers."

The Texas Co., New York City. W. H. Kershaw, Gen. Mgr. "Most profitable show of its kind."

Titan Truck Co., Milwaukee, Wis. J. C. Millman, George Streicher and A. P. West. "More than pleased with results of show."

Truscon Steel Co., Younstown, O. B. C. Briody and W. H. Kelly. "Best business any show ever brought us."

Turbine Sewer Machine Co., Milwaukee, Wis. P. A. Fuchs and F. H. Fuchs. "Expect to derive great benefit from exhibit."

W. S. Tyler Co., Cleveland, O. A. E. Reed and J. H. Jackson. "Exhibit a success and worth every penny spent."

Van Dorn Iron Works, Cleveland, O. M. R. Duffy and F. G. Smith. "Splendid show—well worth our time and money."

Wallis Boiler Co., Chicago, Ill. W. Ortman. "Best piece of advertising we ever had."

Warner Manufacturing Co., Beloit, Wis. M. A. Potter. "Everyone will know what the show is when I say everything is O. K."

Warren Bros. Co., Boston, Mass. C. S. Graham. "Can only say it's the best ever."

Western Wheeled Scraper Co., Aurora, Ill. H. B. Bushnell and J. E. Huber. "This show has been well worth our expense and time."

George D. Whitcomb Co., Rochelle, Ill. W. C. Whitcomb. "Very successful show from a sales standpoint."

The White Co., Cleveland, O. E. C. Buchan. "Better business here than at any other show."

David White Co., Milwaukee, Wis. P. H. Phillipson, Gen. Mgr. "A wonderful show—we'll have more space next year."

Wizard Plow Co., Batavia, N. Y. S. J. Hunt and F. L. Averill. "More Business than at any other show."

Wood Hydraulic Hoist & Body Co., Chicago, Ill. Mr. Kerr, Dist. Mgr. "Very well pleased with show in general."

Wyoming Shovel Works, Wyoming, Pa. G. E. Geer, Sales Mgr. and H. G. Potter, Vice-Pres. "Show is very satisfactory —many orders taken."

Estimates by the Denver, Colo., Tourist Bureau for 1921 show that fully 600,000 persons motored through the Denver mountain park system last year. The motor visitors to Rocky Mountain National Park in Colorado aggregated 273,737, being more than 100,000 of the combined visitors to the Yellowstone and Yosemite National Parks.

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

Founded January, 1892

E. L. POWERS
Editor

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Cable Address: Gudrodes, New York

Copy for advertisements must reach the New York office by noon on Tuesday of the week before date of issue if proofs are to be submitted.

Copy for classified and other advertisements where proofs are not required will be accepted until noon on Monday of the week of issue.

Articles by road builders are solicited. They should be short and, if possible, accompanied by photographs. Those accepted will be paid for at current rates.

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Vol. LXII January 25, 1922 Number 4

THE CHICAGO CONVENTION AND SHOW

The convention and show in Chicago last week under the auspices of the American Road Builders' Association mark another milestone in the growth of the road building industry—an industry which has become recognized as one of the greatest of the country. The event not only brought the leading road builders together in a great convention, but the exhibit feature showed in concrete form the advance that has been made in the production of labor-saving machinery and the methods employed in the construction and maintenance of public roads. While complete figures covering the attendance are not available, it is certain that no such similar event ever had anything like the attendance of road contractors, engineers and highway and street officials. On other pages of this issue will be found the story of the convention, together with a list of the exhibitors at the show.

In reporting the show, efforts were made to get an accurate expression of opinion from all exhibitors as to the benefits derived. Our reporter, however, failed in some cases to secure the desired information and when asked the cause of his failure, replied that the exhibitors were too busy with prospective customers to be questioned. It is worthy of note, however, that every exhibitor interviewed was loud in his praise of the show and the opportunities for business which it afforded. There were, all told, 177 exhibitors. Without question, the display was the greatest aggregation of road building machinery equipment and materials ever assembled. It is estimated that more than $1,000,000 worth of machinery was sold during the exposition.

The attraction of the show feature was so great that it no doubt kept many from attending the sessions of the convention. In spite of this, however, the sessions were well attended and the earnest discussions of the papers and addresses were of great value. It was particularly noticeable that very few of the scheduled speakers failed to appear and those who did, sent their papers to be read. While the technical program covered practically every phase of road building, the greatest interest seems to have been shown in the questions of highway finance and transport. The sentiment appeared to be in favor of transportation bearing a greater portion of the cost of maintenance.

The American Road Builders' Association is to be congratulated upon the success of its convention and show. Its dominant position in the highway field has been fully established.

OPERATING EXHIBITS DURING SESSIONS

During the years spent in the development of the show feature of its activities, the executives of the American Road Builders' Association have held steadfastly to the idea that the sessions of the convention should be held in the same building as the exhibition. This is as it should be. There is every argument in its favor. Unfortunately, however, for the Chicago event, the only hall available for meetings in the Coliseum was directly above the operating machinery, and owing to the noise, the management was compelled to enforce the rule compelling exhibitors to shut down during the sessions. This was a hardship for many of the exhibitors, who felt that they had paid for the privilege of demonstrating the operation of their machinery to prospective customers. It was a difficult problem for the management to contend with, but it is worthy of note that the exhibitors acquiesced with little protest. It is to be hoped, however, that before another show is held, the management may be able to solve any noise problems connected with the convention and show and thereby permit the operation of machinery at all times without in any way interfering with the sessions of the convention. Suggestions are in order.

MANY SURPLUS ARMY TRUCKS ALLOTED

More than 27,000 motor vehicles have been distributed by the Bureau of Public Roads of the United States Department of Agriculture among the various states for road building purposes. Up to Oct. 31, a total of 27,198 had been so distributed, including 1,800 retained by the Department of Agriculture for use on roads in the National Forests and in connection with the administration of the federal aid act. These comprise virtually all the surplus motor vehicles turned over to the Department of Agriculture by the War Department to be distributed under the Wadsworth-Kahn act among the states for road building purposes.

Problems of the Highway Contractor*

By HENRY H. WILSON†

Having been intimately associated with the movement toward collective organization in the highway construction industry, which has developed during the past two years, I shall attempt to interpret those things which are held, by some of the leading representatives of this industry, to be the most vital of their problems. It will only however be possible to very briefly touch upon each one under the several headings under which their relations may be said to function. Many problems of administration and technique will have to be omitted entirely. Bearing in mind too the present necessity and demand for lowered costs in every line of industry, I shall pay particular attention to these problems, a solution of which will, it is believed, result in decreased costs for highway building and in a dollar to the taxpayers for every dollar expended.

International Relationship

The greatest problems of contractors fall under this heading and many of these problems are of their own creation. Perhaps the greatest of all relates to the education of themselves. This education should be conducted along the lines of cultivating skill, integrity and responsibility, and eliminating the old time jealousy and distrust through encouragement of a spirit of cooperation and mutual helpfulness in every member of the industry. The individualistic tendency of the contractor dates from a time limited only by history and is believed to be more largely responsible than anything else for many of his existing problems.

It is good business for contractors to educate their competitors; it is good business for them to discuss each other's problems, construction and administrative methods; it is good business to get each other's viewpoint; it is good business and eliminates waste both to the contractor and owner, to seek out the best means consistent with first-class work and to assist in standardization of methods and equipment along these lines; it is good business to secure added protection by all legitimate means. Organized construction can best promote these things. Sane, honest and common-sense competition is better for all interested in highways than the destructive, individualistic tendency which has so often, in the past, made highway construction a financial shamble and brought upon it disrepute as a business proposition. The comparatively limited number of concerns which have been able to survive in the business, with profit, over any considerable period of years, is the proof of the foregoing points.

The Public

Mark Twain said, in substance, that it had always appeared to him that the Devil never had a fair show; that, notwithstanding certain religious sects had issued Bibles and other injurious pamphlets against him, he had never been given a chance to state his case, and there must be something to be said upon his side. Until the past two or three years, there has not been cohesive action upon the part of constructors necessary for the proper presentation of their case at the Bar of Public Opinion. The better minds of the industry recognize that our problems must be solved with the welfare of the public constantly in mind and that it will be idle to attempt that which is not economically sound. At a recent highway conference, made up of representatives from almost every line of business directly or indirectly associated with highway work, a large number of axioms were displayed. The one receiving the most marked comment and unanimous endorsement read:

"If I knew you and you knew me,
'Tis seldom we would disagree."

Bearing this in mind, as well as the limits outlined above, it is to the interest of the body politic that the contractor should be better known and understood and it is one of his problems to place himself in such a position.

Lower contract prices are imperatively needed to secure greater mileage of roads for the public. The greatest reduction which can be brought about, would doubtless result if certain risks now assumed by the contractor were assumed by the state. It is almost superfluous to say that a contractor can figure closely on work in direct proportion as elements of risk and uncertainty are eliminated. In many states the assumption of these elements of risks and uncertainty are required by the organic law and can be escaped by access to public opinion as expressed through legislative action. To bring about a change in these laws which will facilitate a more balanced and equitable form of contract, through the elimination of the above elements, as far as possible, and thereby permit contractors to conduct estimating and preparations along well established business principles in the problem not only of the constructor but of engineers and all others interested in highway building, who desire decreased costs, and better stabilization of the industry.

It is also the problem of the highway builder to use his influence to create a public sentiment which will countenance better paid and better qualified engineers and inspectors. Contractors recognize that one of the greatest problems confronting highway commissions and chief engineers is a salary scale which will permit them to employ men more competent and experienced. It can be stated as a truism that good contractors invariably find engineers and inspectors satisfactory in direct proportion as the latter possess integrity, intelligence and

* Paper presented at Nineteenth Annual Convention of the American Road Builders' Association, Chicago, Ill., Jan. 16-20, 1922.

† Winston & Co., New York, N. Y.

experience and that the employment of high-class men will invariably justify itself in an ultimate saving to the taxpayers.

As was pointed out in the recent report of the Highway Committee of the Associated General Contractors of America, the present investment in highways is held by many to be economically unsound and the elimination of all expense possible, without sacrificing quality, should benefit through better satisfaction upon the part of the public and a consequently increased volume of work for all interested.

Highway Departments and Engineers

The problem of the contractor here is to cooperate in pointing out those requirements of the specifications which entail increased costs without any commensurate advantage and those requirements which can be waived in the interests of economy without sacrificing quality. It is doubtful if there will ever be a set of specifications written for highway work which will not be susceptible of improvement, therefore, it should be the endeavor of all interested to constantly strive for improvement and economy in same. Many clauses now current suggest that the writers thought only of the equity lying on one side of their subject.

Contractors should endeavor to cultivate a broader and more sympathteic attitude, within their own ranks, as to the viewpoint and limitations of commissions, engineers and other public servants in their dealings. Many of us realize that, under present laws, the difficulty with commissions and engineers (as to many changes for which we are asking) lies not so much in their failure to recognize the just principle to apply as in finding a means to apply it practically.

Closer acquaintance and mutual discussion, in a collective way, between contractors and engineers, will do much to bring about that better understanding and cooperation which will stimulate, and react in, added technique, larger medium of standardization, more economy of methods and consequent reduced costs. Organized construction is and has been moving in the direction of greater cooperation and it is hoped that engineers and others interested will not fail to recognize the mutual advantages to be derived therefrom. One of our problems is to bring about a realization, by all engineers and inspectors, that the contractor is their partner and not their bondman in a great work. When highway engineers, contractors, material producers, equipment manufacturers and all others interested come to complete realization of the fact that they are confederates in the most stupendous work of our age (and one by which the future will doubtless chiefly judge our civilization) highway building will be reborn and most of our problems will have been solved.

"It ain't the guns nor armament, nor funds that they can pay,
but the close co-operation that makes them win the day.
"It ain't the individual nor the army as a whole, but the everlastin' teamwork of every bloomin' soul."

In the matter of specifications, we believe it to be one of our problems to secure the settlement, by an impartial referee (when desired by either party) of dispute between ourselves and engineers as to the interpretation of specifications and matters of equity.

As was pointed out by William B. King of the Washington (D. C.) Bar, in his very able address before the Associated General Contractors of America last year: "The engineer writes what, in his judgment, has a certain meaning. The easy evolution of authority to the architect or engineer to decide all uncertainties, directly encourages vagueness in writing specifications." An engineer, with every desire to be fair, will oftentimes interpret specifications too much in the light of what he had in mind to safeguard when he wrote or adopted the specification in dispute. The working out of standard specifications for the country as a whole will save much effort and expense for which the taxpayers now pay.

Labor

Uniform and fair treatment of labor and possibly more uniform wages and working conditions for the various classes of skilled labor employed upon highways are believed to be a problem from which benefit can be derived. If it were possible to develop some coordinated industry in the northern and border states, whereby highway labor might be retained the year around upon some productive work, constructors would be able to secure greater economy and added efficiency from their organizations. Cooperation between concerns working in the same locality, in the matter of labor, will go far towards stabilizing conditions and creating greater efficiency.

Materials

One problem here relates to the working out of a form of contract with material producers which will be a standard for the industry and more binding upon both contracting parties; in fact, it is believed that a solution of this cannot fail to reflect itself in decreased costs. The experience of many contractors with material contracts, during the war and post-war period, had a direct tendency to increase contract prices.

Another problem under this heading is the matter of responsibility for rejected material. Some producers refuse to accept responsibility for material condemned after unloading, while some engineers refuse to make final inspection until the material is unloaded. Uniformity of practice and understanding in this matter will remove an element of anxiety and loss to many constructors and will, doubtless, reflect itself in lower contract prices. Through the close cooperation of all, other inconveniences, delays and expense can be avoided.

Transportation

Our chief problem in this connection is to assist the railroads and indirectly the public, in the elimination of waste and expense, by so designing work and unloading facilities as to provide for prompt release of cars. During the working season, thousands of railroad cars are devoted entirely to transportation of highway materials. Much expense can be avoided and added efficiency se-

cured for the railroads through a study of car movements and routings.

The *Engineering News Record*, in a recent editorial, charged that, during the past three years of intensified paving construction, contractors had done practically nothing towards standardization of methods and equipment. Standardization of equipment holds great possibilities for efficiency and economy and organized construction is already moving in this direction. Here again the working out of standard specifications for the country at large will do much to facilitate matters as it frequently happens that equipment suitable for construction in one state is not suitable in another.

Surety Companies

One of our greatest problems lies in our relation with the surety companies, and it will, perhaps, be interesting to call attention to the following resolution adopted at a recent convention of highway contractors.

"Resolved, That it is the sense of this meeting that a reduction in the cost of highway construction can be effected through a reduction by the surety companies of the premium now charged for contract bonds; and, it is believed this reduction will be justified by a more careful investigation upon the part of the surety companies, of contractors whom they bond."

This resolution was adopted, with a request to a prominent surety executive present at the conference that he present same to the surety companies' association for consideration and action. It is not going too far to allege that much demoralization has been caused in our industry (and much indirect to the taxpayers through delayed and unsatisfactory work) by the bonding of irresponsible concerns. Within the past ten years, there has been an increase of approximately 100 per cent, in bond premiums and, within the past thirty years, the increase has been comparatively greater.

In conclusion, it is believed that, when the problems outlined herein have been solved, there will be fewer abandoned contracts, less loss, trouble and expense to the public in being deprived of the use of its highways through delayed and unsatisfactory work, a saving to the taxpayers in cheaper work resulting from the elimination of improper risks in contracts, lower engineering costs through more expeditious execution of work, better work by better satisfied constructors, a better satisfied public and a better and cleaner highway construction industry.

Cost Keeping on Highway Construction*

By A. R. LOSH†

From an extensive investigation made about six years ago by the Bureau of Public Roads it was found that generally very little cost keeping was done by state and county highway departments on highway work. Where practical and efficient cost keeping existed it was usually found to be on work done by the state highway departments. There was at that time very little interest manifested by public officials in cost keeping on highway work. A similar condition with respect to cost keeping existed to a large extent among road contractors. At this time there had been a long period of almost uniform conditions with respect to labor, materials, types of construction, and processes. The successful contractor had grown up in the business and had rules and methods of his own for estimating, which were based on years of experience and he did not feel the need of cost statistics. The greater portion of the highway work of the time was done by the type of contractor referred to as having his hat for his office and his check book for his cost record of the job. The more substantial contracting organizations and especially those which did not confine their operations to road work exclusively carried cost keeping records on their road work. As a rule highway engineers attempted to obtain the costs on contract work but generally did not give sufficient attention to the details of cost keeping to obtain complete and reliable data.

It has developed from a recent preliminary study of highway cost keeping conditions that there has been a substantial improvement since the investigations previously referred to were made. Of recent years, due to a scarcity of contractors in the highway field, it has been necessary for states and counties to do a large amount of highway work with day labor forces and the value of cost keeping as a check on expenditures and as a guide to efficient management has led to the installation of cost keeping of some kind on this work. In addition to serving these ends much valuable cost data have been accumulated which form an important part of the fiscal records of the work and have also been used advantageously in placing other work under contract. The advantages of keeping cost on day labor work are generally recognized but there are divergent views with respect to keeping costs on contract work. As a result it will be found that with one state highway department cost keeping on contract work is incidental to the inspection and the resident engineer or inspector is to considerable extent left to his own devices in this regard, while with another state highway department the cost keeping is one of the important functions of the residency and not considered a side line by any means.

When the cost on contract work is considered advantageously the method followed is either to select the jobs which will supply the information desired or to cover the entire program and keep costs on all contracts. In either case there should be sufficient force available to handle the inspection and cost keeping properly. It will be diffi-

* Paper presented at Nineteenth Annual Convention of the American Road Builders' Association, Chicago, Ill., Jan. 16-20, 1922.

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cult if not impossible to secure satisfactory results unless the inspectors or cost keepers receive specific instructions as to what they are to do, are supplied with standard recording and report forms, and their cost keeping supervised as well as their inspection work. It is not meant to infer that cost keeping is of the same importance as the inspection of the construction, but that if cost keeping is to be carried on at all it should have more than casual attention from the administrative authorities.

The advantages resulting from keeping costs on contract work are usually given as follows:

1. Valuable cost data are secured which may be used for estimating purposes.
2. The department has available necessary cost data for making settlement with contractor where unforeseen conditions are involved.
3. Engineers and inspectors receive training in use of cost data and making up of estimates.
4. Provides a means for analyzing cost of work which may lead to development of more economical designs and methods.
5. In some cases of assistance to the contractor who may not have an adequate cost system.

The Bureau of Public Roads has abandoned the practice of keeping costs on all of its contract jobs but is instead keeping costs on all day work and on such contracts where it is thought the data will be advantageous to the Bureau. It will prove advantageous to a state highway department to collect cost data on a number of representative contracts each year as a general check on the cost of its designs and also to determine the margin of profit contractors are getting.

The increasing use of cost keeping by contractors is even more pronounced than in the case of the state and county organizations. This is due principally to the unsettled conditions during the past three years which have made estimating more difficult and renderd as practically useless many cost data and hypothetical rules used a few years ago. New construction methods, and especially those processes requiring a more extensive use of equipment have also increased the need of cost keeping. Possibly the increasing number of engineers in the contracting field has had some effect in turning contractors to cost keeping. It will be found that highway contractors are now working individually and through their organizations for more systematic and businesslike methods in estimating work and in the keeping of construction costs. While no uniform method for keeping highway costs has as yet been suggested by contractors' organizations, practically all contractors are now keeping costs on their work. Some of the systems used are almost of the check-book class in simplicity but they vary from this to a codified system of accounts divided and subdivided to collect cost of labor, materials, equipment and supervision on various operations. It appears that the present tendency is for highway contractors to develop cost keeping systems comparable with those in use by the building industry.

The primary purpose of cost keeping is to ascertain the actual cost of production. Not what the cost should be but what it is. For a contractor's use the cost system should furnish reliable data on current costs. In this way a periodic check on the cost of the work, which is an indication of the efficiency of the organization, is available as a managerial aid to the contractor or his superintendent. The function of a cost system is of especial value on highway work where there are usually a number of operations under way simultaneously on different parts of the job and in consequence all of the workmen are not continuously under the observation of the superintendent. Next in the importance to the contractor is the value of cost data as a guide for estimating future work. The increasing complexity of highway construction is making cost keeping of more importance. The large sums of money now involved in road contracts mean more items of work, new processes, and additional operations over former requirements. To estimate the cost involved without comparable cost data is becoming too costly a hazard. It is not enough to know that there was a net profit on the job, but in order to use the data for estimating purposes it must be known by items and operations the actual cost of production.

In the construction industry it is not practicable to determine unit costs with the provision and refinement that obtains in the manufacturing industry. This is due to the variable nature of the construction product and the frequent change of conditions. Also, since conditions are not identical on any two jobs cost data from one is only an approximate comparison for another. For these reasons cost data must be used as a guide or measure in forecasting future costs. Cost data on new or unusual methods of construction and on the use of various plant units are of particular value as similar conditions are likely to be encountered in the future and a basis for cost estimates is available.

It is believed that the proper basis for a cost system is the four principal elements of cost allocated to the units of production.

(a) Labor Costs
(b) Material Costs.
(c) Equipment Costs
(d) Administration Costs or General Expenses.

The products of highway construction to which these cost elements are assignable are road parts. Fundamentally these parts are:

(a) The right of way
(b) The roadside, shoulders, and grade
(c) The travelled way or roadway proper
(d) Drainage channels or ditches and drains
(e) Drainage structures or bridges and culverts
(f) Supplementary structures of miscellaneous road parts, such as guard rails, retaining walls, guide posts, etc.

Thus, there are six major products on each of which

there may be four elements of expense or cost; consequently, we have 24 cost divisions. Since general expense is not ordinarily ascertained directly on production but is pro rated to the various operations the actual cost divisions with which the cost keeper is directly concerned are reduced to 18. It is believed that this is the minimum number of cost divisions which will provide a satisfactory highway cost keeping system. These cost divisions are susceptible of much further analysis by breaking them up into various operations. For example, a square yard of concrete roadway is one of the unit products. The cost divisions for this are three, *i. e.*, labor, materials, and equipment. To these three may be added the pro rated general expense. For further analysis, this square yard of roadway may be subdivided into subgrade finishing, placing of forms, hauling materials, mixing concrete, placing concrete, curing concrete, etc. This illustrates how the system may be extended to meet the requirements of any desired analysis.

In placing the cost items against the appropriate construction items the greatest difficulty appears to be in correcting the equipment costs and "administration costs." It is the experience of the Bureau of Public Roads on its own work that these items are given less attention in the preparation of estimates and in the segregation of cost to construction items than the more nearly definite items of "labor" and "materials."

The handling of equipment costs has been greatly simplified by the use of a rental factor computed to cover fixed charges, depreciation, overhauling, lost time, storage, and supervision. In the case of its own plant the Bureau has prepared rental schedules for all units of equipment having a useful life of more than one working season and costing more than twenty-five dollars. Small tools and those which are usually worn out on one job are handled the same as materials. This plan has been in operation three years and except for a change from a monthly to a daily basis it is practically the same as originally developed. It has proven satisfactory on both day labor and contract work of the Bureau. A rental factor of this kind is necessary where current costs are determined for purposes of management. If greater accuracy is desirable for fiscal purposes an annual appraisal of the equipment may be made and the depreciation, repair, storage and other charges pro rated to the projects which have used the equipment.

As general expense is not usually assignable directly to units of construction and many of the expenditures do not come to the attention of the cost keeper on the job there is a tendency to overlook this element until the project nears completion, at which time the cost is pro rated to the work completed. The result is a sudden jump in unit costs. Even with this apparent defect this may prove the best method to adopt as it greatly simplifies the handling of general expense items. Where limited funds require careful attention to gross expenditure on a project this method is not recommended. Occasionally it is found that the general expense is quite high in starting a job and if this is pro rated to the small accomplishment during the first few weeks of the work there are shown abnormally high unit costs which are not a true indication of conditions. Two suggestions are offered for the handling of general expense. First, it will be found advantageous to divide general expense into two parts, one of which includes those costs which are assignable directly to the project and the other the general administration costs of the organization which must be pro rated to all its various projects. This latter part need not be considered in current cost reports as it does not in any way affect the efficiency of the construction organization on the project. This part of the general expense may be apportioned to the project upon its completion. The second suggestion is that the amount of general expense (project) taken up and pro rated on current reports be a percentage of the total probable general expense, which percentage to be not greater than the percentage of the project completed. For example, if the project is only 10 per cent complete, pro rate to completed work not more than 10 per cent of the total probable general expense. On projects where the cost of "moving in", "camp installation", "organizing", and "disorganizing" is of a considerable amount the unit construction costs are liable to be materially affected if this entire cost is distributed before the work is well under way.

A cost keeping system to be successful must be based on certain fundamental principles. First of all it must be designed to furnish the particular information sought. This feature can not be too strongly emphasized as not infrequently much more time is spent in perfecting quasi-scientific forms, codes, and procedure than is given to working out a system for getting at the cost of doing work. The system devised must be reliable and accurate to a practical extent. In so far as field procedure is concerned simplicity is a very important consideration and it should be such that the required data can be successfully compiled by foreman and timekeepers. The effectiveness of the system will depend to a great extent on the celerity with which the unit costs may be ascertained. Unless the cost of doing the work can be determined easily and promptly its value as an aid to efficient management is lost. Some consideration should be given to making the cost system adaptable to the general work of the organization and not design it entirely for an individual job or set of conditions. It requires time and considerable patience to get a system in working order and frequent changes in forms and instructions should be avoided as they are generally disconcerting to the men in charge of construction work. It must be understood that cost keeping ties in the general bookkeeping scheme of the organization and is not to be operated independent of the regular accounting. While the cost-keeper and bookkeeper make different use of the information, the basic data used should be the same. One of the reasons cost keeping has not received more encouragement in the past from engineers and contractors has been the ques-

tion of its cost. A system laid out along the lines indicated and designed to give the information needed for the proper supervision or administration of the work of an organization need not be expensive considering the volume of business it handles. It is when a system is developed beyond the requirements of the organization that cost becomes an important consideration.

A review of the present status of cost keeping on highway work indicates that it is still very much in a formative stage. There are some excellent systems in operation in many of the state highway departments and among the larger contracting organizations, but on the larger part of the extensive highway program cost keeping as practiced leaves much to be desired. A great step forward would be accomplished by a general classification of cost keeping terms. Many of these as now used are subject to several interpretations. Engineers and accountants could materially improve the situation by reaching a common understanding in this regard.

As an indication of the present interest in highway cost keeping it is interesting to note that since the publication by the Bureau of Public Roads of its Cost Keeping Bulletin more than five thousand copies have been distributed.

NOTES OF NEW YORK STATE ROAD BUILDERS' ASSOCIATION

John W. Whalen, a retired road contractor, prominent for more than fifty years in railway, canal and highway construction celebrated the fiftieth anniversary of his marriage this month in Albany, N. Y. Mr. Whalen retired from the contracting business five years ago. He was connected with the building of the upper part of the Mohawk and Malone Railroad in the Saranac, Lake Clear and Malone section, and constructed the first railroad in San Domingo from Puerta Platt to Santo Domingo.

The appeal of the State of New York from a decision of the Appellate Division, fourth department, reversing the decision of the Court of Claims in dismissing the claim of John H. Gordon of Albany, N. Y., against the State was argued on January 13th before the Court of Appeals. This claim comes under the Knight Law passed by the Legislature in the year 1919, authorizing the Commissioner of Highways to cancel all highway improvement contracts which were begun after the beginning of the World War and allow the Court of Claims to settle claims of contractors who were not in default on their contracts, for increased cost of materials and labor they were compelled to pay for work done, and relieving them from further liability on their contracts.

A. E. Rose, Deputy Attorney General, attacked the constitutionality of the law on the ground that it was giving the credit and money of the state to private individuals, and that the Legislature was prohibited from granting extra compensation to public officers and contractors.

Benjamin P. Wheat, appearing for Mr. Gordon, contended that the law is constitutional as it was the recognition of a moral obligation of the state to protect contractors from loss by reason of increase in the cost of the work contracted for due to war conditions.

At the letting which took place on January 10, there were contractors from New York, New Jersey, Pennsylvania, Massachusetts and Vermont, numbering 142, bidding on nine state highway contracts. Competition was very sharp. There were 51.03 mi. of road in the letting representing a cost of $1,300,335. There were 23 bidders on the Angelica-Canaseraga, Allegany County contract, and 28 bidders on the Pavilion-Batavia, Genesee County contract.

The annual meeting of the New York State Road Builders' Association took place on Tuesday, Jan. 10, at the rooms of the association, Journal Building, Albany, N. Y. The meeting was largely attended, and matters of vital interest to all contractors was discussed.

In the evening at 6:00 P. M. at the Hampton Hotel a Banquet was given which was attended by the members of the association and associate members, as well as many contractors doing work in New York State.

John H. Gordon, President of the association, was master of ceremonies. The speakers were Commissioner Sisson, Mayor George R. Lunn, of Schenectady, N. Y., Dr. P. T. O'Reilly, Holyoke, Mass., Ransom Rowe, President of the New England Road Builders' Association, Frederick Stuart Greene, former Highway Commissioner, and Judge James A. Parsons.

The menu cards at the banquet were enclosed in a cover resembling a steam roller and were considered very appropriate, and were carried away by the diners as a very interesting souvenir.

LEWIS S. SADLER DIES

Lewis S. Sadler, State Highway Commissioner of Pennslyvania, died suddenly on January 20 at his home in Carlisle. Mr. Sadler took office three years ago, during which time 1,000 mi. of state highways have been completed.

Commissioner Sadler's wife died about six years ago and his father died last year. His two brothers are, Sylvester B. Sadler, a justice of the Supreme Court of Pennsylvania, and Dr. Horace T. Sadler, of Carlisle.

During the entire time Mr. Sadler was State Highway Commissioner he did not turn in an expense account. His traveling expenses, hotel bills, etc., incurred during his inspection of state highways were paid out of his own pocket. When the last legislature gave the commissioner the power to fix the salaries of every attache of the department, he placed the salary of the assistant commissioner in excess of that of the commissioner.

MEETINGS

Calendar of Coming Meetings

Jan. 27-28—Western Paving Brick Manufacturers' Association—Annual meeting, Kansas City, Mo.

Feb. 12-17—Conference on Highway Engineering.—Eighth Annual Conference, University of Michigan, Ann Arbor, Mich.

Feb. 21-22—Kentucky Association of Highway Contractors—Annual meeting. Louisville, Ky. Secretary, D. R. Lyman, Louisville, Ky.

June 4-6—American Association of Engineers—Annual convention, Salt Lake City, Utah. Secretary, C. E. Drayer, 63 E. Adams St., Chicago, Ill.

June 26-July 1—American Society for Testing Materials—Twenty-fifth annual meeting, Atlantic City, N. J. Secretary, C. L. Warwick, Engineers' Club Bldg., Philadephia, Pa.

UNIVERSITY OF KENTUCKY TO HOLD HIGHWAY CONFERENCE

A conference on highway economies and highway transport will be held January 31 and February 1 at the University of Kentucky, Lexington, under the auspices of the university, the Highway and Highway Transport Education Committee of the United States Bureau of Education and the Kentucky State Highway Department. The sessions of the first day will be presided over by W. E. Freeman, Acting Dean, College of Engineering of the University of Kentucky. Dr. Frank L. McVey, President of the university will deliver the address of welcome. Sessions on the second day will be presided over by Col. H. Green Garrett, Chairman, Virginia State Highway Commission.

The following papers will be presented: "The Relation of the United States Bureau of Education to Highway Development," by Dr. John J. Tigert, U. S. Commissioner of Education; "The Future of Highway Transport," by E. S. Jordan, President, Jordan Motor Co.; "Recent Developments in Highway Engineering Research," by Dr. W. K. Hatt, National Research Council; "The Purpose of Highway Development in the United States," by Thomas H. MacDonald, Chief, U. S. Bureau of Public Roads; "Kentucky's Road Problem," by Joe S. Boggs, State Highway Engineer of Virginia; "The Scope and Purpose of Federal Aid in Behalf of Improved Highways and Its Relation to the States," by John M. Robinson, Congressman from Kentucky; "The Farmer and Good Roads," by J. M. Feltner, University of Kentucky; "Possibilities of Maintaining Lower Cost Surfaces," by W. N. Bosler, Principal Assistant State Highway Engineer of Kentucky; "Safety First Education in the Public Schools," by Miss Harriet Beard, Supervisor of Safety Education, Detroit, Mich; "The Uses of the Highway," by Dr. J. G. McKay, University of Wisconsin; "The Training of Engineers for the New Highway Building Program," by D. V. Terrell, Professor of Civil Engineering, University of Kentucky.

SOUTHWESTERN INTERNATIONAL HIGHWAY ASSOCIATION FORMED

To improve the roads in the Southwest and with the aim of affording a motor highway from Montreal to Mexico City, an association has been formed known as the Great Southwestern International Highway Association.

The highway route will touch such cities in the order named as Quebec, following the New York-Albany-Quebec route through Montreal to Rouse's Point, N. Y., thence to Malone, Watertown, Rochester, via the Theodore Roosevelt International Highway; Rochester to Buffalo, Erie, Cleveland, Cincinnati, via the Ohio Market Road No. 1; Cincinnati to Covington, Ky., thence to Frankfort, Louisville, West Point, Hardinsburg, Cloverport, Owensboro, Henderson, Morganfield, Marion, Smithfield, Paducah, Wickliffe, to Cairo, Ill., where the trail will cross the Mississippi River to Bird's Point, Charleston, Sikeston, Dexter, Poplar Bluff, thence to Little Rock, Ark. From Little Rock the trail will continue to Texarkana, Texas; Dallas, Waco, Austin, San Antonio to Laredo, and then across the border to Mexico City, via the Lone Star route.

The highway will be marked by a 12 in. black square with two inches of white at the top and bottom and a 2 in. diagonal orange stripe.

PERSONAL MENTION

C. D. Shawver has been appointed city engineer of Cheyenne, Wyo.

C. A. Poole has been appointed city engineer of Rochester, N. Y.

Norman E. Brown has resigned as director of public works of Pittsburg, Pa.

E. H. Willis has been appointed county engineer of Burlington County, New Jersey.

L. E. Prouty has succeeded S. M. Adams as county engineer of Mobile County, Alabama.

C. D. Buck has been appointed chief engineer of the Delaware State Highway Department.

George M. Coughlin has been appointed director of public works of Bridgeport, Conn.

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TABLE OF CONTENTS

Selection of Mineral Aggregates for Concrete Roads. By Duff A. Abrams 67

Use of Standardized Paving Brick. By W. W. Horner. 70

Highway Cost Reduction 74

The Highway Outlook. By Thomas H. MacDonald . 78

Maricopa County, Arizona, Has Immense Road Program 77

Federal Aid Program Being Drafted 80

State Highway Work in Montana 80

EDITORIAL:

Progress in Highway Engineering 73

MEETINGS.

Calendar 79

New Jersey Highway Convention 79

University of Michigan to Hold Highway Conference 79

PERSONAL MENTION 80

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Selection of Mineral Aggregates for Concrete Roads*

By DUFF A. ABRAMS†

The widespread use of concrete in road construction is one of the most remarkable developments in recent years. The severe service to which such concrete is subjected has given rise to much experimental work in an effort to determine the materials and methods of construction which give the best results.

The aggregate comprises about 80 to 85% of the total volume of materials used in concrete; consequently this type of material is of considerable interest to all who are engaged in concrete road construction. On account of the great weight and expense of shipping long distances, it is essential that aggregates near at hand be used if they are at all suitable. Due to the almost endless variety of materials available, the preparation of a proper specification and methods of test are most complicated. The requirements to be met must be dictated to a certain degree by local conditions and economic considerations. Many researches both in the field and in the laboratory have been carried out during the past few months or are now under way which throw much light on the proper requirements for aggregates for concrete roads.

General Requirements

Aggregate for concrete road construction should be clean, structurally sound and inert in the presence of cement and water. These properties imply also a certain quality which we may term weather-resistance. A wide variety in size and grading may be used with satisfactory results.

A digest of the specifications for concrete roads of the state highway departments shows that about 80% of the states have some requirements for the abrasive resistance of coarse aggregates. Generally the minimum size of coarse aggregate is placed at ¼ in. and the maximum size at 1½ to 3 in. The requirements for fine aggregates are somewhat less specific; the grading is generally specified as finer than ¼ in. In some instances certain requirements for smaller sieves are included. Mortar strength tests are generally required.

Aggregate Tests

Tests of concrete aggregates are made for two distinct purposes: (1) to establish underlying principles, and (2) to determine whether a given sample conforms to certain predetermined standards.

The two purposes in testing mark the distinction between research and inspection.

Tests of aggregates have been undergoing marked changes during the past few years. The earliest tests of coarse aggregate were adapted directly from those made on rocks for macadam roads. Experience has shown that the tests for hardness, toughness and cementation value are of lititle use in judging of the quality of an aggregate for concrete.

It is unfortunate that standard tests for concrete aggregates have not thus far been developed and generally accepted. The American Society for Testing Materials, the Bureau of Public Roads and other organizations have done much toward standardization but much remains to be done. In view of the absesnce of generally accepted standard tests, I can probably do no better than to describe the tests used in the Structural Materials Research Laboratory, Lewis Institute, Chicago.

Several thousand samples of both fine and coarse aggregates from all sections of the United States have been subjected to test during the past seven years. In many instances samples were sent in by engineers or contractors from concrete road jobs. Large numbers of samples were collected especially for research purposes. The methods of the American Society for Testing Materials have been followed where such methods have been recommended. It should be noted, however, that in many instances the A. S. T. M. methods have only recently been published as tentative standards and there has not

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been sufficient time for them to come into general use.

Fine aggregates are subjected to the following tests:

Sieve Analysis—Percent coarser than Sieves No. 100, 50, 30, 16, 8 and 4. (Follow Tentative Method A. S. T. M., 1921.)

Silt—Loss of weight and 500-gram sample, due to washing in shallow pan and rejecting wash water. (Follow A. S. T. M. Standard Method for Test for Quantity of Clay and Silt in Sand.)

Unit Weight—Puddle into 1/10 cu. ft. cylindrical measure in 3 layers. (Follow A. S. T. M. Standard Method of est for Unit Weight of Aggregate for Concrete.

Impurities in Sand—Digest sample in 3% solution of sodium hydroxide, observe color after 24 hr. (Follow A. S. T. M. Tentative Method of Test for Organic Impurities in Sands for Concrete.)

Mortar Strength—Compression tests of 2 x 4-in. mortar cylinders at ages of 7 and 28 days, using 1:3 mix by weight and by volume. Make parallel tests on 1:3 Standard sand mortar. (Follow A. S. T. M. Tentative Test for Compressive Strength of Portland Cement Mortars.)

Coarse Aggregates are subjected to the following tests, so far as the quantity of material permits:

Sieve Analysis—Percent coarses than U. S. Sandard Sieves No. 8, 4, ⅜ in., ¾in. and 1½ in. (Follow A. S. T. M. Tentative Standard.)

Unit Weight—Puddle with 1/5 or ½ cu. ft. cylindrical measure in 3 layers. (Follow A. S. T. M. Method of Test for Unit Weight of aggregate for Concrete.)

Abrasion—Deval abrasion tests: follow A. S. T. M. Standard method if aggregate is satisfactorily graded; otherwise use test as modified by Rea, Mattimore or Abrams.

Concrete Strength—Compression tests of 6 x 12-in. concrete cylinders at ages of 7 and 28 days, using 1:4 mix with local concrete sand, graded up to No. 4 sieve. Make 5 cylinders on different days from separate batches, mixed by hand. (Follow Tentative Methods of Making Compression Tests of Concrete of the A. S. T. M.)

Wear of Concrete—Use 8 x 8 x 5-in. blocks in Talbot-Jones rattler; 1:4 mix; relative consistency 1:10; test at 28 days. Mold specimens in metal forms and finish by hand. Make 5 specimens.

Sampling of Aggregates

Tests of aggregates are more than worthless unless sampling is properly done. Particular care must be used in sampling under the following conditions:

1. Coarse aggregate in care,
2. Coarse aggregate in stock pile,
3. Rock in native ledge,
4. Sand or gravel in undersloped pit.

The Tentative Methods of Sampling Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Material, recently published by the A. S. T. M. should be followed where applicable.

In the preparation of test samples in the laboratory the method of quartering may be used, or better yet, some form of sample splitter.

A very common mistake is the furnishing of samples which are entirely too small for tests. Complete tests require 50 lb. of fine aggregate and 100 lb. of coarse aggregate.

Sieve Analysis of Aggregates

The sieve analysis of aggregates is important, but it must be properly interpreted. Good concrete can be produced of aggregate of almost any size and grading (if of good structural quality), providing these characteristics are taken into account in designing the mix to be used. The division of aggregate into fine and coarse is largely arbitrary, but should be preserved as a means of securing uniformity in the grading of aggregate in successive batches of concrete.

The practice of mixing of fine and coarse aggregates in fixed proportions without regard to size and grading should be discouraged. A number of researches have been published during the past two or three years which indicate methods of dealing with this problem; all such methods are based on the sieve analysis of the aggregate. Elaboration of these methods is not within the scope of this paper.

The following from the tentative specifications of the Joint Committee on Concrete and Reinforced Concrete seems to place the grading of fine aggregate on a proper basis:

"Fine aggregates shall range in size from fine to coarse, preferably within the following limits:

Passing through No. 4 sieve—not less than 95%
" " No. 50 " —not more than 30%"

It will be noted that the grading is not mandatory; if fine aggregate of other gradings are used the proportions of cement, coarse aggregate and water should be such as to give concrete of the desired strength.

The writer wishes to urge the general adoption of the sieves named above for concrete aggregate. They now have the backing of the Bureau of Standards, he A. S. T. M. the Joint Committee on Concrete and Reinforced Concrete, as well as other influential organizations. These sieves are on a scientifically sound basis in that the width of the clear openings of each sieve is exactly double the width of the next smaller one, and the ratio of clear opening to wire diameter in the different sieves follows a definite law.

In this connection it may be well to say a few words on the relation between the sieve sizes mentioned above and the sizes of material produced by commercial screens using perforated plates. A little consideration will show, and the investigations of the Bureau of Public Roads have proven, that the size of aggregate produced by a commercial screen is determined by one or more of the following factors, which have no relation whatever to the size of the openings:

1. Thickness of plate.
2. Wear on plate.
3. Diameter of screen.
4. Length of screen.
5. Inclination of screen.
6. Rate of rotation.
7. Rate of feed.
8. Wet or dry screening.

In other words, a sieve analysis under standardized conditions is necessary to give the actual sizes of material produced, although it may have been screened at the plant.

There is a marked tendency now to go to larger sizes of coarse aggregate in concrete roads; a number of specifications now admit aggregate up to 3 in.; this tendency should be encouraged.

Silt in Sand

In usual concrete work a small percentage of silt in sand is not objectionable, so long as it does not contain organic impurities and providing an excess of mixing water is not used. However, in the wearing surface of concrete roads, silt is especially objectionable, since it is likely to be drawn to the surface in finishing, hence producing a weak and friable concrete where concrete of the highest quality is needed. The quantity of silt should not be greater than 3% by weight. If sands of higher silt content must be used, the following precautions should be taken:

1. Reduce the quantity of sand to a minimum,
2. Reduce the quantity of mixing water to a minimum,
3. Work surface as little as possible in producing a finish.

The quality of concrete will in any case be improved by following (1) and (2) above.

Unit Weight of Aggregate

The unit weight of aggregate is in general of little value except as a means of arriving at the quantities of materials necessary for concrete of a given mixture. In the case of slags and aggregates of unusual types, the unit weight may be of value in furnishing some notion of the character of the material. The old notion that heavy aggregates are better than light ones has little basis in face.

Organic Impurities in Sands

Organic impurities in sand is objectionable, due to the fact that such materials either greatly retard or entirely prevent the setting and hardening of cement. Such impurities generally come from carelessness in stripping the overburden from sand and gravel pits.

The colorimetric test with sodium hydroxide which originated in this laboratory is becoming generally accepted as a satisfactory criterion for this purpose.

Mortar Strength of Fine Aggregate

The compression test is much to be preferred over the briquet test for mortars. The comparison with 1:3 standard sand mortar at 7 and 28 days gives valuable information, providing the test is properly interpreted. If three sands give mortar strengths of 70%, 100% and 130% of standard sand, it does not follow that concrete made from these sands will show the same strength-ratios. In fact, they will show about 90, 100 and 110%. The reason for this lies in the fact that in concrete the sand is only, say, one-third the total aggregate, hence differences in strength of concrete, due to variations in the sands, may be expected to be only about one-third those found in sand mortars. Sands which fall below standard in mortar tests may be used with good results, providing the mixtures are modified accordingly.

Abrasion Test of Aggregates

While the abrasive resistance of coarse aggregates, as determined in the Deval machine, is generally specified, it should be stated that many engineers are beginning to question its value in selecting materials for concrete roads. In general, the standard test for macadam rocks cannot be made through inability to secure pieces large enough; the test is meaningless when applied to pebbles. These conditions have led to the use of modifications of the old standard test. Three modifications have been extensively studied in this laboratory.

The abrasion tests may be described briefly below. All methods use the Standard Deval machine, run at 30 r. p. m. The percent of wear is in all cases based on material rejected by the 1/16-in. mesh sieve after test

Method. Characteristics

American Society for Testing Materials—50 pieces weighing 5000 gm., run for 10,000 revolutions.

Mattimore—Same as A. S. T. M., except that test cylinders provided with 1/16-in. slots which rejects fine materials as produced.

Rea (Modified)—5000-gm. sample (or equivalent volume, in case of materials or unusual weight) 2500 gm. ⅜ to ¾, 2500 gm. ¾ to 1½-in. 6 cast-iron balls, 1⅞ in. diam., 1000 revolutions. Rea's original method required the use of ½, 1 and 2-in circular screens.

Abrams—4000-gm. sample (or equivalent volume); 2000 gm. ⅜ to ¾; 2000 gm. ¾ to 1½ in.; 10 cast-iron balls, 1⅞ in. diam., 2000 revolutions.

The last method has the merit that it can be made in one hour, whereas the other tests require over five hours. This is our principal justification for proposing this method. The sieve sizes conform to the U. S. standard and the percentages of material of different sizes are such they can be selected from nearly any sample of crushed material which is presented for test.

The relative wear produced by the various tests may be shown from the following values which were secured from parallel tests in a recent investigation:

	Relative Wear				
Method	Limestone (12)	Trap (4)	Granite (2)	Sandstone (4)	Slag (3)
A. S. T. M.	100	100	100	100	100
Rea Modified	505	400	1160	686	167
Mattimore	315	223	225	208	175
Abrams	250	204	555	513	74

The percent of wear of each material by the A. S. T. M. method was taken as 100. The numerous inconsistencies in the table are probably due as much as anything to the variations in the performance of the A. S. T. M. Method when applied to materials of widely different types. It seems apparent that the A. S. T. M. test should be abandoned for this purpose.

There has been a marked tendency to lower the limiting percent wear for crushed rocks to be used in concrete roads; this is partially due to recent changes in the type of traffic and to a growing realization that the wearing resistance of the aggregate has only a remote bearing on

the wearing resistance of the concrete. This subject is referred to below under wear tests of concrete.

Concrete Strength

Testing aggregate by means of compression tests of concrete is not necessary unless the aggregates present some unusual characteristics; and in general is not necessary in routine inspection work. Such tests furnish the best information for research purposes and should be encouraged. The methods recently published in tentative form by the A. S. T. M. should be followed in making such tests.

Wear Tests of Concrete

Wear tests of concrete by means of the Talbot-Jones rattler furnish an excellent method for research purposes, but are not practical as a routine method of inspection. A ring of 10 separately-molded blocks 8 in. square and 5 in. thick is fastened to the rotating head of the machine, where the finished surfaces are subjected to the tumbling action of a 200-lb. charge of cast-iron balls for 1800 revolutions, requiring about 1 hour. The results of several thousand tests of this kind will be found in the published reports of the S. M. R. L. A recent series of tests which has not been reported in detail shows that the type and quality of the aggregate produced less effect on the wearing resistance of concrete than is usually supposed; and that rather wide changes in grading of coarse aggregate produced relatively little difference in wear of the concrete.

It should be stated that there is a well-defined relation between wear and strength; the factors which produce high strength, produce low wear.

It is believed that further study of data now on hand in tests carried out by the speaker will bring out valuable information on the influence of the quality of the aggregate as revealed by the various abrasion tests and the strength and wearing resistance of the resulting concrete.

Need for Further Research and Standardization

The foregoing remarks make apparent the great need for further research and standardization of methods of dealing with concrete aggregates.

Field tests now under way by the Bureau of Public Roads and by the State Highway Departments of Illinois and Pennsylvania may be expected to give important results on the relative merits of different aggregates. The Bureau of Public Roads, a number of state highway departments, and other laboratories have carried out laboratory investigations of aggregates which have thrown light on the properties which must be required for good results.

Concluding Remarks

No attempt has been made in this brief review to suggest a complete specification for aggregate for concrete roads; however, certain principles which should govern the selection and use of aggregates are given.

There is a marked tendency to disregard minor features in specifying concrete materials and to base final conclusions on the quality of concrete produced.

High grade aggregates are only one of the many requirements of good concrete; the best aggregates do not insure good concrete if the methods of proportioning, mixing, placing and curing are faulty.

Use of Standardized Paving Brick*

By W. W. HORNER†

We who have been particularly proud of the growing importance of the industrial engineer have watched with much interest the work of Mr. Hoover's committee, of the American Engineering Council, on the elimination of waste in industry. Therefore, to municipal engineers at least, the results of the recent conference, called by the Department of Commerce to consider the possibility of elimination of waste in the paving brick industry through standardization of the product, are most gratifying. At this conference fourteen engineering and technical societies met with representatives of the government departments, and of the paving brick industry, and discussed the elimination of excess sizes and varieties of brick.

Briefly, the number of varieties was reduced from sixty-seven to eleven, all of which can be made from three sizes of clay column. There remain as accepted standards three depths of brick, that is, 3, 3½ and 4 in., and two widths, 4 and 3½ in. More specifically, we are to have 3-in. brick in 4-in. width in both plain wire cut and with the moulded lug. Also the side wire cut lug brick in a 3½ in. width. The same three styles are provided in the 3½-in. depth, and there is included in addition the repressed brick in the 3½x3½ in. dimensions. All 4-in. brick are 3½ in. in width, and include the repressed type, and the side wire cut lug type in both the ordinary paving brick, and in the hillside brick. Also the 3-in. lugless brick may be laid on edge, making a 4-in. depth of brick with a 3-in. width plain side wire cut.

Laying of 3-in. brick flat instead of on edge may require a less number of brick per square yard, but as the prices of brick are governed by the weight it is not a question of the number of brick; furthermore, a small lug on the brick to provide spacing naturally reduces the weight as compared to the weight of a square yard of the lugless type.

With this great achievement secured in the factory end of the paving brick industry, it is interesting from

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the engineering viewpoint to analyze the use of this brick, that is, to determine their treatment to the best advantage by the other great industry involved, the one which provides brick pavements for our streets and roads. In this industry there might occur not only the waste of poor organization methods, but a possibly much greater waste in poor design and construction.

Considering first the depth of brick, the writer feels that the 4-in. depth provides all that is needed for the heaviest traffic, and that the 3½-in. brick may be used to good advantage, that its use is technically and economically sound for moderate traffic and is a factor where the cost of transportation enters materially into the cost of the finished pavement. The 3-in. brick cannot be so easily disposed of. While it may give satisfactory service for some time under moderate traffic, the writer feels that it has inherent defects which should be seriously considered by the engineer in designing the pavement. The first of these lies in its large surface area as compared with its depth. (With any type of pavement the bond of the surface must be much more insecure with the three inch than with the other varieties.) With a 4x8½ in. surface it is absolutely necessary to secure a perfect bedding with the brick, in order that it may not be broken under wheel impact. The mere bedding of the brick under the weight of a 5-ton roller will be sufficient to break many of the units before the pavement is completed. The writer has had experiences of this character where 3-in. brick were used on a cushion of screenings or of sand and cement in the semi-monolithic type of pavement, the breakage being so great as to make the actual construction costly.

On account of the thinness of the brick wearing surface the effect of temperature stresses in the cement grouted pavements is extremely destructive, and it would seem highly advisable to consider the 3-in. brick only with bituminous fillers, if at all. The writer wishes to question at this point whether the life of the 3-in. pavements which we are now laying will be sufficient to justify the small saving in first cost involved in the use of this depth of brick. This question may be given emphasis in view of the results of the recent impact tests of the Bureau of Public Roads on pavement slabs.

The next question confronting the engineer is the selection of the style of brick to be used. Aside from the hillside brick, which are only valuable for a special purpose, one has the choice for the 4-in. surface between the old style repressed brick, with or without lugs, and the side wire cut lug brick.

In making a decision on this point the conclusion of Messrs. Goldbeck and Jackson, of the United States Bureau of Public Roads, as published in *Public Roads* of February, 1919, are of particular interest. "Paving brick with well-formed contact lugs are to be preferred to brick without lugs. Paving brick with square edges are to be preferred to brick with round edges." The City of St. Louis, in investigating the condition of its brick streets in 1914, all of which had been repressed lug brick with cement grout filler, came to the conclusion that among the outstanding defects in these older pavements was the failure of the grout to adhere to the round edges of the repressed brick, and the spelling off of surface laminations under temperature stresses, and under the wear of steel tire traffic. As a result of this investigation, and in the desire to secure a more satisfactory space for grouting, the repressed brick were eliminated from the St. Louis specifications, and side wire cut lug brick have been used exclusively since that date. This decision seems to be well justified by the report of the accelerated wear tests of the Bureau of Public Roads recently published, in which it was noted that "The tests would indicate that in resistance to wear the wire cut lug brick ranks above the repressed," and again "Also, the fillers, both asphalt and cement grout, offer considerably more protection and support to the edges of wire cut lug than to those of the repressed brick." That the conclusions here drawn are receiving general acceptance is evident by the decreased production of repressed lug brick, which has fallen from three hundred twenty-three million in 1914 to about seventy-three million in 1920, as compared to the total production of the two years of four hundred fifty-one million in 1914 and three hundred and one million in 1920.

In the 3½-in. depth the same considerations are involved as between the repressed and the side wire cut lug brick. In this depth, however, the engineer will still have the choice of a 3½-in. vertical fibre lug brick, and of a 3½-in. plain wire cut brick without lugs. The vertical fibre lug brick will possess many of the advantages of the side wire cut lug brick. Its principal disadvantages in comparison are the large uniform lugs which cut the filler space up into small chambers more difficult to fill and to waterproof the foundation, and in the smooth sides which cannot be quite so satisfactory in regard to the adherence of the filler as is the rough side offered by the wire cut lug.

The plain wire cut lugless brick has been the subject of much controversy in recent years. This brick was originally brought out by the Paving Brick Manufacturers' Association in 1919, in what was apparently an attempt at standardization. While thoroughly in accord with the necessity for standardizing on a few types, engineers generally have been unable to approve the choice of this type as a standard. The writer expressed his opinion of this matter that year, and desires to repeat with emphasis the statement then made. "The lugless brick means a brick with very small and indefinite spaces for joint filling. All our experience has indicated that one of the greatest defects in brick paving has been incomplete joint filling. That this experience is quite general has been indicated by the increasing use of lugs and the employment of other methods for providing a wide, free space for filler penetration." In the same issue Mr. R. Keith Compton, Chairman of the Baltimore Paving Commission, states that "Lugs are absolutely necessary for the proper flow, no matter what filler is used."

After a thorough investigation the brick committee of the American Society for Municipal Improvements, at the meeting of the society in 1921, recommended a revised specification which provides for regular repressed brick with lugs, for wire cut brick with wire cut lugs, and plain wire cut brick with lugs for cement grout and bituminous filler, but eliminating entirely the type which some manufacturers have been urging as a standard. If Mr. Hoover is correct, that the consumer is the engineer, this decision by the most important committee of engineers having any connection with this matter should be final.

All the considerations applying to the 3½-in. brick apply with equal or greater value to the 3-in. brick, with the possible exception that the 3-in. side wire cut lug brick, being only 3½ in. in width, presents a more normal relation of surface area to depth than does the 4-in. width. The writer has already expressed his doubt of the ultimate value of the 3-in. brick for paving purposes, and would only suggest further that, where used at all, all details of construction should be as nearly ideal as possible, including a proper provision for joint spaces to secure a satisfactory penetration of the filler.

Aside from the character of the brick used, a satisfactory brick pavement surface involves also the proper design of the bedding course and filler. For the bedding course three materials are in common use. First, the sand cushion, which was at one time universal, but which has been discarded in a great number of instances. Second, the sand-cement mixture providing the semi-monolithic type of pavement; and, finally, the so-called monolithic type involving the laying of the brick on the wet concrete. While good pavements have been secured with a sand cushion in some localities, sand in many places has been found unsatisfactory. The sand cushion should never be used except where a satisfactory grade of sand is available, and should certainly not be used with a cement grout filler. On the other extreme, the so-called monolithic type has rarely been found to live up to its name, as temperature stresses in the pavement are inclined to create a movement of the wearing surface, which ultimately breaks the bond. It is to be highly recommended, however, where construction conditions permit of its use economically, for the reason that it is sure to permit of a true bedding of the brick. The sand and cement mixture has been found quite satisfactory. It permits the facility of construction which a sand cushion does not, and with it a smoother surface can be secured than is usually possible with a monolithic type. While it requires careful watching to see that the cushion is not broken while the cement is taking the initial set, it is otherwise simple to handle, and the ultimate strength of the cushion is at times surprisingly high. Of the three types the writer considers it the most valuable in brick paving, regardless of the kind of filler used.

At this time opinion seems to be about equally divided in the choice of filler as between cement grout, bituminous, or bituminous mastic. Where the brick is laid on a strong concrete foundation supported by a well-drained soil, the writer invariably prefers the cement grout as giving to the wearing surface a slab strength over small areas which is of value. If on flexible foundations or on clay soil subject to frost and heaving, a bituminous type of filler is probably a safer choice. When properly handled it is somewhat easier to secure good penetration with a bituminous filler than with cement grout. It has been argued that this ease of penetration with bituminous fillers justifies the omission of lugs, but an examination of recent pavements around the country, and reports from engineers in the technical press, do not bear out this contention. There is apparently a great deal of so-called vertical fiber pavements laid without lugs, in which the filler fails to penetrate materially, and is squeegeed over the surface in the form of an asphaltic or mastic mat. The defect is not apparent in the new pavement, but in the course of a short time, depending on the amount of traffic, this mat breaks up or wears off, and the brick have been found to be loose and the joints largely empty.

The filler in a brick pavement has three functions to perform. First, to hold the brick units solidly in position in order to create and maintain a smooth, continuous pavement layer. Second, to waterproof the pavement and prevent the entrance of moisture into the cushion with consequent disintegration and heaving; and finally, to protect the edges of the brick from breaking down under traffic. It is evident that to properly carry out these functions the filling of the joints must be complete, and that the bridging of the joints and the creation of the mat of wasted material which is seen in so many vertical fiber pavements is not good engineering practice.

The writer believes that the lugs heretofore used on both wire cut and repressed brick are somewhat larger than necessary for this purpose, and that in the case of the bituminous filler a ⅛-in. lug will be satisfactory.

In view of the possibilities outlined above it seems advisable to raise the question whether efforts to reduce the cost of the pavement in some cases are not carrying us into a design that is economically unsound, and whether the ultimate waste in pavement failures on this account may not be far greater than the waste we have been attempting to eliminate in the standardization of brick. The writer believes that the consumer, in this case the engineering profession, should seriously consider whether conservative specifications such as those of the American Society for Municipal Improvements should not be more strictly adhered to even where the cost involved would be somewhat greater than the first cost of certain of our pavements. If these specifications were adopted quite generally by the profession there would not only be eliminated this possibility of waste, but there would be further elimination in the styles of brick in that the plain wire cut lugless brick in both 3 and 3½-in. depths could be dropped, and that possibly it might ultimately be wise to drop also the other styles of 3-in brick.

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PROGRESS IN HIGHWAY ENGINEERING

Although the road building industry during the past five years has grown to be the greatest construction industry in this country, much work has yet to be done before it stands on equal footing with the older engineering industries. Upon reflection, such is to be expected, for a glance at the development of the older departments of engineering shows that progress was exceedingly slow, especially in the early stages. Little road work was done in this country prior to the present century and very little effort was made to place road construction upon a scientific basis until a comparatively few years ago.

With the hundreds of millions of dollars now becoming available for road work each year, the stupendousness of the task of providing an adequate highway system for this country is being impressed upon the minds of many road builders who realize that, although highway engineering has emerged from its swaddling clothes, it has not yet reached maturity. The papers presented at the recent convention of the American Road Builders' Association clearly show this to be the case—that the principles of pavement design are not fully established and that the specifications for paving materials are not entirely satisfactory. In other words, highway engineers do not know with any degree of certainty the best design to use for a paved highway, neither do they know exactly what materials are the most serviceable. But let it be understood that highway engineering is making progress and that each year adds to the sum of scientific knowledge in this field.

Many of the papers presented at the Chicago convention dealt with the attempts being made to place road building on a more scientific basis. One of the most important papers dealing with the professional side of road work was that of A. T. Goldbeck, Testing Engineer of the U. S. Bureau of Public Roads, who reviewed the more recent researches conducted by this bureau. Considerable space in this journal has recently been devoted to reviewing the work of the U. S. Bureau of Public Roads and it is unnecessary to point out that these researches are playing a very important part in aiding highway engineers to arrive at rational ideas of pavement design.

A more concrete example of direct value of highway research was pointed out by Clifford Older, Chief Highway Engineer of Illinois, who stated that as a result of researches conducted by Illinois, approximately $1,500 per mile is now being saved on road construction in that state.

W. W. Horner, Chief Engineer of Sewers and Streets, St. Louis, Mo., reviewed the work of the National Paving Brick Manufacturers' Association in reducing the number of varieties of paving brick from 66 to 11. This paper, which is printed elsewhere in this issue, shows that highway engineers have the cooperation of material manufacturers in the work of placing road building on a scientific basis.

Another instance of this critical examination of present road building methods and materials is seen in the paper of Duff A. Abrams, Professor in charge of the Structural Materials Laboratory, Lewis Institute, Chicago, Ill., who urged "further research and standardization of methods of dealing with concrete aggregates", pointing out at the same time that many tests now being applied to concrete aggregates are of little value.

Another paper presented at the American Road Builders' Association convention which further illustrates the trend of thought in road building circles, was a paper by L. M. Law, Chief Chemist, New Orleans Refining Co., reviewing the development of asphalt specifications and pleading for simpler and more scientific present-day specifications.

Thus it is seen that leaders in the highway field are busily engaged in attempting to solve the problems of road design and materials. Much has been accomplished, yet, to use the trite but terse expression, the surface has barely been scratched. However, the future is full of promise, and as H. E. Breed said in his paper at the Chicago convention, "we are going to be able to build roads within necessary financial limits that under the traffic permitted by law will be practically indestructible."

A Tax on Gasoline in Louisiana of 1 ct. per gallon went into effect the first of this year. It is expected that this tax will yield about one million dollars annually for highway work.

Highway Cost Reduction

Text of a Report Submitted by the Highway Division of the Association General Contractors to the Executive Board of the American Association of State Highway Officials

To build a system of hard surface roads that will carry the country's expanding rural and interurban traffic may entail a prohibitive financial burden to the states unless present construction costs are reduced. The investment in improved highways at the present is held by many persons to be economically unsound, and doubt has been expressed as to whether the taxpayers would continue to vote for bond issues unless a greater mileage were obtained by their appropriations. To bring about lower construction costs is obviously a matter of vital concern to state highway departments and it is also an important matter to construction companies, who will profit by an increased volume of work.

New Economic Situation

It is generally sensed that we are about to emerge from the much discussed period of deflation and readjustment, and, at this time, the outlook indicates that many unit costs which were once well established have been so disarranged that they cannot return to their former level through deflation alone. A number of reasons for this situation are readily discerned: Labor scales in the basic industries producing gravel, cement, asphalt and other materials may, with labor strongly organized, remain high for some time to come. Certain material sources have been depleted and production at other sources is more expensive. Moreover, the action of governmental agencies in passing laws and increasing transportation rates has added expense to construction which is entirely independent of deflation. These things have brought about a new economic situation and therefore a different set of unit construction costs.

Present costs may undergo some additional deflation, and the gradual trend of labor and materials throughout the coming period may effect a decrease; but, to bring about the substantial reduction needed in the near future, it will be necessary to improve construction methods and to cut down the so-called indirect or overhead expense.

Numerous items of expense have crept into highway work by creating unnecessary obligations and requiring over-rigid guarantees. They have increased both the direct cost of production and the contingent costs, and it is in these two fields that state highway departments and contractors can most advantageously cooperate. The department can assume certain obligations more economically than the contractors and can remove certain contractual provisions which add unnecessary expense to a contract. The contractor can then eliminate these uncertain items from his estimate and can improve the efficiency of his methods.

Possible Cost Reductions

Items of road building cost which may be reduced by joint action of state departments and construction companies depends upon certain contracting practices. These practices fall naturally under the following heads:

1. Receiving bids and awarding contracts.
2. Administering contracts.
3. Principles of contracts and specifications.
4. Matters of legislation.

The various expenses arising under these four divisions are discussed from the viewpoint of contractors who have been building roads extensively during the past two years.

I. Receiving Bids and Awarding Contracts

Before highway construction developed into its present gigantic proportions, contracts were but a matter of labor, materials and a small amount of overhead. Materials were usually supplied locally and transportation did not constitute a problem of any moment. Now, however, the situation is different. Road builders must compete with other industries in obtaining materials, labor and transportation, and to produce economically they must conduct their operations with an eye to the activities of those industries. This means that they must plan far ahead, and obtain sufficient work to introduce the economies of quantity production.

The crux of economical road building is a full season's work with as little moving as possible, but this condition cannot exist if highway contracts are split into small or isolated sections. It is necessary that each outfit be placed, wherever possible, on a section large enough to furnish a season's work. Otherwise several items of needless expense arise. These expenses are as follows:

(a) Loss of straight time salaries and production time consumed in moving from one project to another and in organizing each new project.

(b) Extra freight charges and loss of production time through delay of the carriers.

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*From the "Bulletin" of the Associated General Contractors of America.

"This report was issued by a committee composed of Stanley D. Moore, Moore & Young, Waterloo, Ia., Chairman, Highway Division, A. G. C. C. V. Burghart, Bates & Rogers, Chicago, Ill., and Percy Cranford, Cranford Paving Co., Washington, D. C., and submitted to the Executive Board of the American Association of State Highway Officials. It was drawn up to point out those things exclusive of direct construction costs, which increase the cost of hard surface roads. If certain of these factors can be changed or eliminated, contruction companies will unodubtedly be abl eto submit lower bids."—Editor, "Bulletin."

(c) Extra cost of setting up and dismantling the plant between projects.

When work is awarded in short sections on which a well equipped plant cannot be used advantageously, contractors cannot invest in modern, efficient plants. Unless they do purchase and operate such equipment there is scarcely a possibility of securing the economy of quantity output.

Full Season's Work on One Job

By awarding contracts in lengths great enough to provide a full season's work for a modern plant, a better utilization of the construction season is possible, and the items enumerated may be held to reasonable proportions. Even further economies of this nature are possible when contracts are awarded well in advance of the actual construction season. In fact, the time of awarding is now regarded as one of the most important factors in reducing highway costs.

It is almost universally recognized that contracts should be awarded in the fall or early winter, thus enabling construction companies to do much of their preliminary work in the off season and to utilize concrete-pouring weather for increasing their pavement output.

Fall Letting Promises Economies

Fall letting is a practice in which many engineers and contractors see promise of great economy, and a general increase in the efficiency of road building is expected through its adoption. This increase of efficiency and a corresponding decrease in cost are made possible by the following:

(a) A nucleus of well trained men retained over winter to serve as a skeleton for the new organization.

(b) Elmination of dead time for permanent field organization by employing them on preliminary winter work.

(c) Elimination of one shipment of the plant, which is moved direct from the old work to the new without going into the contractor's storage yard.

(d) Adequate time for investigating and planning.

(e) Better transportation service during early months of the season, without possibly preferential freight rates at that time.

(f) Lower costs in the basic industries on account of a longer production season.

The total influence of fall letting affects so many factors in highway work that it is difficult to foretell what reduction of cost it would bring about, but contractors have estimated that the total cost of highway projects could thereby be reduced 5 or 10%. The importance of fall letting in relation to eliminating the waste from industry has made it the subject of correspondence between the Secretary of Commerce, Mr. Hoover, and the governors of all states.

II. Administering Contracts

The field experience of contractors has shown that most dissensions which arise between representatives of the highway departments and representatives of the contracting companies are due to an honest misunderstanding. Unless the cause of these misunderstandings is removed by exchange of views and discussion, they sometimes develop into cankerous enmity which interferes with proper execution of the work. Some means of providing such exchange is needed.

To encourage a mutual understanding of each other's problems in Iowa, a school for engineers, inspectors, superintendents and foremen was established prior to the beginning of new work. It served to acquaint each party with the difficulties encountered by the other and thus laid the groundwork for more satisfactory relations between the department and its contractors. In the Iowa school the engineers and contractors evolve plans for executing the work, or if such plans have already been determined they see that all parties understand the plan and encourage suggestions for improvement. They also explain many of the questions which may be expected to arise from the details of any project and confer on other matters of mutual interest or benefit. This school, it was found, practically removed the element of personal friction and misunderstanding and undoubtedly resulted in economy. Similar schools will probably result in more satisfactory contract performance if adopted in other states.

Local Conferences

Another step towards removing many difficulties which arise in the field, and one which has already proved valuable, is the establishment of local conferences between engineers and contractors. These conferences would investigate local conditions which affect the work, determine economical methods for doing unusual work, or arrange to take advantage of unusual conditions in the locality with the object of economizing on the work. Such conferences conduct discussions that lead to better economies in road building and consequently to lower construction costs.

III. Principles of Contracts and Specifications

Contracts and specifications have frequently been regarded as delicate grounds in discussions between engineers and contractors, but it is nevertheless well understood that requirements commonly included in these documents cause unnecessary expense to the state. The state obviously guarantees, but as the scope of these is increased it adds an element of uncertainty to the cost against which no construction company dare fail to provide insurance. This insurance, whether placed with an insurance company or carried as a contingent expense, increases the cost of roads. Insurance of this nature can often be carried more economically by the state, and if so carried would make possible a reduction in the cost of surety bonds.

Limit Risks to Contractors

If the risks against which construction companies are required to furnish protection were limited to those things over which the companies can exercise some measure of control, and if they were not required to assume responsibility for damage from practically every cause,

they could eliminate a number of contingent expenses. Some of the contingencies occur so rarely that the cost of insuring against them can be more economically assumed directly by the state. The infrequent occurrence of a contingency, however, will not justify a construction company in failing to provide insurance. One occurrence of some of these contingencies is sufficient to bankrupt a construction company and the company must, therefore protect itself financially. This the bonding company also does in establishing its rate. By eliminating from specifications those hazards and responsibilities which can be more economically assumed directly by the state, a lower rate on surety bonds can doubtless be obtained.

Irresponsible Bidders Raise Costs

Bonding companies say that the rate could be further reduced if the state would exercise a more comprehensive interpretation of the term "responsible bidder". The ability to furnish bond is inadequate proof of responsibility, because irresponsible bidders do obtain both state highway contracts and bonds, and their failures raise the bond rate. If the state were careful to secure bidders who are actually responsible the rate could not only be reduced but a reduction of bond could be made as sections of the work were completed and accepted. The savings thus made would reflect directly in the construction estimate. They would also reduce the total amount of money required to finance the work and hence the interest charges.

Reduction of Interest Charges

Interest charges can also be reduced by the following procedure:

(a) Limit the percentage obtained by the state to an amount which experience has shown to be necessary.

(b) Limit the money retained so that amount held when the work is 50 or 60% complete.

(c) Provide for a specific date and method of payment upon which the construction company may depend —thus eliminating the expense of emergency financing.

(d) Return certified checks and make awards promptly so that bidders receiving no award may look immediately for other work.

Interest charges in themselves are not a large per cent. of the cost of building roads but the procedure here suggested to reduce them will indirectly reduce other expenses. When all of these items are combined the saving is significant. Any action which limits the uncertain costs and enables accurate estimating results in lower bids.

Classification of Excavation

Among the uncertain factors which prevent accurate estimating is the matter of classifying excavation. A lack of accurate classification in excavation always introduces an uncertainty which will not allow an estimator to get down to the bottom price. He cannot risk striking hard material with an earth price and if, for example, hard pan or a stiff gumbo is anticipated and but a single or two-grade classification is provided, the price must obviously cover the cost of such material. If, however, a classification is provided which segregates the various grades of material, a construction company can safely bid its lowest price on each.

Similar to the lack of classification is the practice of lumping different kinds of work under a single unit price. In all such cases an uncertain cost is introduced which does not permit the lowest unit prices. The remedy is obviously to separate into units those items which vary in cost and can be determined separately.

Overhaul Introduces Uncertainty

Still another uncertainty is caused by payment for overhaul. If a construction company is obliged to work under a predetermined overhaul price, it knows that under many conditions the price will not cover the expense, and this contingency must also be provided for, if the work is to be performed at a profit.

Likewise, the contract provision governing changes in the work usually creates a dangerous contingency. This provision allows one department to increase or decrease the work without making any adjustment in price for the resulting change in cost. Every quantity eliminated carries with it a certain portion of overhead which stands as a loss and, unless the construction company is assured the work will go practically as planned, it cannot estimate with any degree of accuracy. The consequence is another item of insurance.

Misplaced Cost Expensive for State

A common practice in estimating, and one which finds favor with state highway departments, is to place all items of cost, or a proportionate part of them, where they properly belong. This cannot always be done if the so-designated "percentage of profit on force account" is based only on direct labor and materials. The usual percentage allowed is the same as that adopted years ago, yet any engineer knows that the proportion of direct labor has decreased while the indirect expense, such as equipment, has increased. The usual percentage does not always cover the cost. This the construction estimator knows and must take care of it in some other place. Such misplaced cost may in the end be more expensive for the state. A better plan is to account the work so that such expense can be definitely determined and settled. For this the contract can readily provide.

One other saving which the contract may bring about is that of inspecting materials at their source. Rejecting faulty aggregates after they have been unloaded precludes the construction company from recovering their cost. Inspection at the source would eliminate the waste of materials rejected on the work. This item of expense, like various others here cited, under "Contracts and Specifications," is of the indeterminate type and it is not possible to say definitely what economy it will bring about, but every construction company knows that, if these suggested change were instituted, it could and would submit lower bids.

IV. Legislation

Highway engineers and contractors have frequently agreed upon procedure which ought to be followed in

building roads and which would bring about lower costs, yet the department is prevented from acting on account of existing laws. Legislation frequently interferes with proper functioning of the state highway department in matters of which the department is best able to judge. It is to the interest of both department and construction companies to secure a repeal of such legislation and to work for the enactment of constructive laws which will develop proper state highway systems.

Several specific changes in contracting practices, which contribute to more economical work, can be brought about by revising certain highway legislation. The changes are:

(a) An improvement in the form and character of road securities, which would facilitate their sale, reduce the market discount, and prove a saving to the state.

(b) A repeal of laws which prohibit payment for materials delivered. This would reduce financing charges and permit adequate storage of material.

(c) Delegation of police power to the state highway department's representatives. This would enable them to regulate freely all traffic over roads under construction and would enable better planning of plant layouts and avoid much interruption of work.

Proposed Action

Discussion of the four classifications of cost reductions which are possible in highway work is based upon the experience of road builders during the last two years.

The discussion of cost reduction as developed in this analysis is based upon the experience of construction companies which have been the pioneers in high type road construction. It therefore naturally portrays the situation from the contractors' point of view and may not recognize the necessity of certain practices as they exist. For this reason a similar analysis should be made from the viewpoint of state highway departments. Two such studies would then show the actual possibilities of cost reduction and would produce a satisfactory basis for action. Once having agreed upon the proper cause, engineers and contractors could undoubtedly bring about lower highway costs.

MARICOPA COUNTY, ARIZONA, HAS IMMENSE ROAD PROGRAM

With only three miles of paving yet to be laid, the first half of the Maricopa County, Arizona, highway program is practically complete. This part of the county's paved highway system is covered by the initial issue of $4,000,000. The highway commission is now about to undertake the second part of the program under the additional bond issue of $4,500,000.

A total of 127.5 mi. of Portland cement concrete paving will be laid by January 15, 1922, in completion of the first half of the program. This consists of: 68.2 mi. 16 ft. wide 5 in. at center and 8 in. at edges; 12.4 mi. 18 ft. wide 5 in. at center and 9 in. at edges; 46.9 mi. 16 ft. wide 6 in. at center and 9 in. at edges.

The Maricopa County road program, as carried out under the supervision of the Maricopa County Highway Commission, represents the most ambitious county paving undertaking in the United States and has attracted no end of interest among highway engineers

An outline of the history of permanent highway construction by Maricopa county is as follows:

Jan. 20, 1919—Board of Supervisors appoints County Highway Commission.

May 17, 1919—First issue of $4,000,000 bonds voted for the construction of 283 mi. of paving.

July 9, 1919—Bonds sold to Graves, Blanchett & Thornburgh and associates for $4,032,500.

April 22, 1920—Contract awarded to Twohy Brothers.

Nov. 1, 1920—Actual construction started.

Dec. 31, 1920—Second issue of $4,500,000 bonds voted. This election was called when it was ascertained that owing to high price of cement and freight, the original program could not be completed under the original estimate. Twenty-nine miles were added to the original program, giving a total of 312 mi.

Dec. 8, 1921—Bids opened for sale of second bond issue.

Dec. 9, 1921—County supervisors accept bid of Bankers Trust Company of Denver, and associates, carrying a premium of $300,150 on the masis of 6 per cent bonds.

Dec. 15, 1921—Miles of paving completed, 124.4.

Jan. 15, 1922—On this date was announced that the county had completed a total of 127.5 miles, and in addition to this three miles of bitulihic paving on the Phoenix-Tempe highway, and 7.5 miles of cement concrete paving on the Phoenix-Glendale road. These projects were included in the second half of the county's program and are being constructed by the State with Federal Aid.

All county work has been under the engineering direction of R. C. Perkins, County Highway Engineer. Mr. Perkins adopted a special design in paving which has created no small interest. This calls for a curved subgrade and a heavier thickness of concrete at the edges than at the center, a beveled depression in the subgrade causing an additional three inches of thickness at the extreme edge.

About $600,000 worth of up-to-date highway machinery and equipment have been utilized by Twohy Brothers in the prosecution of this work. Most of the roads have been built from materials taken from the bed of the Salt river at Tempe and handled by the contractors' central washing, crushing and screening plant, and from this shipped by rail to the several set-ups or distributing stations, from which the materials have been carried to the paving mixers by industrial trains propelled by gasoline locomotives and utilizing a maximum of 15 mi. of trackage.

The Asphalt Association has discontinued its Canadian office at Toronto, Can. It is expected that a district office will be opened at Albany, N. Y., from which the Canadian territory will be covered.

The Highway Outlook*

By THOMAS H. MacDONALD†

January of all the months is dedicated to the inventory, the analysis of profit and loss, the casting up of accounts. It is not so much a custom as a necessity. Private business could not succeed long without striking a balance sheet to govern the conduct of the operations. That the varied activities and their attendant expenditures of a people governing themselves must be able to stand up under keen scrutiny and each one justify itself or be eliminated or be materially reduced, is strikingly shown by the strength of the support from the public for the budget plan adopted to control the financial affairs of the Federal Government. A balance sheet has been set up which adjusts the out-go to the income. Further, the proportions of the income to be devoted to the several purposes have been and are being carefully weighed in a comparative sense to adjust them as fairly as may be possible to each other.

There is the universal demand for economy which must be met. There is the insistent demand for the lowering of taxes which must be heeded. These same facts apply to local, state and Federal expenditures and taxes. On the other hand, there is the unemployment situation, the competitive period ahead, and the demand and necessity for internal improvements.

The situation demands wisdom, foresight and leadership of the highest character. Wise expenditure is more necessary than uneconomical saving. Thus the highway outlook is not determined by any narrow or limited consideration but by all the broad social and economic relationships with which the highways have intimate contact.

We need to establish a highway balance sheet, national in extent, on which we set up, on one side:

1. The funds available.
2. The economic situation.
3. Prices and costs for highway improvements.

On the other side,

1. The deferred highway improvements.
2. The returns from highway investments.
3. The need of universal easy and cheap transportation facilities.

Year	Total expenditures, Approximate
1904	$ 59,527,000
1914	240,263,000
1917	279,915,000
1918	286,101,000
1919	389,455,000
1920	500,000,000
1921	600,000,000
1922	*720,000,000

* This is the estimated sum which has been made available but subject to conditions and limitations that will materially reduce the total which is actually expended.

On the basis of the estimated total highway expenditures for the year 1921, the sources of this fund are approximately as follows:

Motor vehicle revenues	19%
State road bonds	7
Local road bonds	33
State taxes and appropriations	12
Federal aid	14
County, township, dist. taxes and ass'mt.	14
	100

Secretary of Agriculture, H. C. Wallace, says: "It would be unfair to say that the unprecedented depression in which we find agriculture to-day is due wholly to the very large increases in freight rates which have been imposed during the past three years, but it is fair to say that those increased freight charges are a large factor in retarding agricultural recovery. If prices now received by farmers for their crops were such as pevailed in 1919 and the ealier part of 1920 they could pay the increased freight rates without serious inconvenience. But farmers are not receiving such prices.

"In Iowa, for example, the farmers are receiving for their corn a price equal to but 65 per cent of the pre-war normal, for their oats but 61 per cent of the pre-war normal, and for their cattle and hogs somewhat less than the pre-war normal. They are paying their hands 132 per cent of the pre-war normal, are paying rent on land values 160 per cent of the pre-war normal, and even since the late reductions are paying freight rates 150 per cent of the pre-war normal. Practically everything the farmer buys is well above the pre-war normal at the point of production, and to those higher prices must also be added the higher freight rates to farms. It is this condition which makes the present state of agriculture so serious. In times past we have seen lower prices for farm crops, but in these times the cost of things the farmers bought were low in proportion. The trouble now is that whereas the prices the farmer receives for his crops are lower than before the war, the price he pays for the things he needs are from twenty-five to seventy-five per cent above the pre-war prices. Hence, the purchasing power of the major farm crops is probably lower than at any time in our history, and this has very much to do with the Nation-wide industrial and business depression."

The conclusions are self-evident:

1. During the period 1910-1920, the potential number of motor vehicles demanding highway service increased more than 1,800 per cent, highway expenditures about 400 per cent.

2. During the period 1910-1914, motor vehicles increased more than 1,100 per cent, highway expenditures about 140 per cent.

3. During the period 1914-1921, motor vehicles increased about 700 per cent, and highway expenditures about 260 per cent of the 1910 figures.

But even these figures do not truly represent the differential between the demands for highway service and our actual production.

* Abstract of paper presented at Nineteenth Annual Convention of the American Road Builders' Association.

† Chief, U. S. Bureau of Public Roads.

MEETINGS

Calendar of Coming Meetings

Feb. 12-17—Conference on Highway Engineering.— Eighth Annual Conference, University of Michigan, Ann Arbor, Mich.

Feb. 21-22—Kentucky Association of Highway Contractors—Annual meeting, Louisville, Ky. Secretary, D. R. Lyman, Louisville, Ky.

June 4-6—American Association of Engineers—Annual convention, Salt Lake City, Utah. Secretary, C. E. Drayer, 63 E. Adams St., Chicago, Ill.

June 26-July 1—American Society for Testing Materials—Twenty-fifth annual meeting, Atlantic City, N. J. Secretary, C. L. Warwick, Engineers' Club Bldg., Philadephia, Pa.

NEW JERSEY HIGHWAY CONVENTION

The New Jersey State Highway Department will hold its second annual state highway convention February 15 to 18 at the Stacy-Trent Hotel, Trenton. The program is now in the course of preparation and a number of instructive and interesting papers will be presented.

UNIVERSITY OF MICHGAN TO HOLD HIGHWAY CONFERENCE

The eighth annual conference on highway engineering of the University of Michigan will be held at Ann Arbor, Mich., on Feb. 13 to 17. The program is as follows:

Monday, February 13—2:30 P. M.

"New State Standard Cross-Sections, Shallow Ditches and Sub-Drainage," by Leslie H. Belknap, Deputy State Highway Commissioner of Michigan.

"State Investigations Covering Grade Reductions," by V. R. Burton, District Engineer, Michigan State Highway Department, and Walter E. Lay, Assistant Professor of Mechanical Engineering, University of Michigan.

Monday, February 13—8 P. M.

Moving Pictures of Road Machinery and Highway Construction Methods, Room 348, Engineering Building.

Tuesday, February 14—9:30 A. M.

"Controlling the Quality of Materials in Highway Construction and Maintenance," by John H. Bateman, Director, State Highway Laboratory, and Assistant Professor of Highway Engineering, University of Michigan.

"Efficient Methods of Providing for Traffic During Highway Construction," by A. R. Hirst, State Highway Engineer of Wisconsin.

Tuesday, February 14—2 P. M.

"Plant Inspection, a Necessity to Insure Good Bituminous Pavements," by Francis P. Smith, Consulting Paving Engineer, New York City.

"Developments in Methods of Constructing Brick Pavements," by Arthur H. Blanchard, Professor of Highway Engineering and Highway Transport, University of Michigan.

Tuesday, February 14—8 P. M.

Smoker: Michigan Union, Second Floor; Henry E. Riggs, Professor of Civil Engineering, University of Michigan, presiding.

"Michigan as a Summer Resort," by Hon. H. S. Earle, former State Highway Commissioner of Michigan

Violin solo by M. L. Casman, Roy D. Chapin, Fellow in Highway Transport.

Songs by Highway Engineering Students.

Musical Selections by Rogers' Orchestra.

"Bituminous Surfaces on Gravel Roads," by Paul D.

Wednesday, February 15—9:30 A. M.

Sargent, Chief Engineer, Maine State Highway Commission.

"State Investigations Covering Dust Prevention on and Preservation of Gravel Roads," by G. C. Dillman, Maintenance Engineer, Michigan State Highway Department, and Herschel C. Smith, Assistant Professor of Highway Engineering, University of Michigan.

Wednesday, February 15—2 P. M.

"Comparison of Sub-Drainage by Deep Side Ditches and Tile Drains," by Charles M. Upham, State Highway Engineer of North Carolina.

"Organization, Management and Methods of Snow Removal from Highways Outside of Municipalities," by Charles J. Bennett, State Highway Commissioner of Connecticut.

Wednesday, February 15—8 P. M.

Moving Pictures of Road Machinery and Highway Construction Methods, Room 348, Engineering Building.

Thursday, February 16—9:30 A. M.

Road Commissioners' Meeting

Frank F. Rogers, State Highway Commissioner of Michigan, presiding.

Reports of representatives of the County Highway Departments of Michigan.

Thursday, February 16—2 P. M.

"Distribution of State Reward Funds," by Frank F. Rogers, State Highway Commissioner of Michigan.

"Maintenance of State Trunk Line Roads in Calhoun County," by G. W. Schneider, Chairman, Calhoun County Road Commission.

Thursday, February 16—6 P. M.

Informal Dinner of Michigan Road Commissioners' and Engineers' Association: Banquet Hall, Michigan Union. President G. W. Schneider, presiding.

Friday, February 17—9:30 A. M.

"Appearance of Highways," by C. F. Boehler, Land-

scape Engineer, Michigan State Highway Department.

"Useful Roadside Planting," by Hon. W. S. Linton, Saginaw, Michigan.

"Growth of Roadside Trees," by A. K. Chittenden, Professor of Forestry, Michigan Agricultural College.

"Relation of Roadside Development to Telephone Companies," by B. R. Marsh, Division Plant Superintendent, Michigan State Telephone Company.

PERSONAL MENTION

J. W. Ackerman, formerly City Engineer of Auburn, N. Y., has been appointed city manager of Watertown, N. Y.

James Logan has resigned as county engineer of Burlington County, New Jersey,. to enter private practice.

James E. Gillespie has resigned as division engineer of the Wisconsin State Highway Department to enter private practice.

James W. Routh has been retained by the Bureau of Municipal Research of St. Paul, Minn., to study street cleaning and refuse disposal problems.

J. A. Courtade has resigned as director of public works of Bridgeport, Conn., and is now manager for Connecticut for the Warren Brothers Company, of Boston, Mass.

F. D. Hudgins, formerly a senior highway engineer of the U. S. Bureau of Public Roads, with headquarters at St. Paul, Minn., has been appointed state highway engineer of South Dakota.

Hugh Crozier, formerly highway engineer for the western district, under the Kentucky State Highway Department, has been appointed assistant engineer at the deparment headquarters at Frankfort.

FEDERAL AID PROGRAM BEING DRAFTED

The Secretary of Agriculture is considering a tentative draft of rules and regulations for the administration of the Federal Highway Act, approved last November, under which $75,000,000 is appropriated for the construction of Federal-aid rods, but will not promulgate them until he has conferred with representatives of the state highway departments. The secretary is impressed with the need for the closest possible cooperation between the Federal Government and the states in the devlopment of the federal aid highway system called for by the act, and the value and serviceability of the system will not be jeopardized by a hasty decision as to the roads which will comprise it or the regulations to be followed in carrying out the purposes of the legislation.

Fifty million dollars of the appropriation became available Jan. 1, and the remaining $25,000,000 was made available upon approval of the act, Nov. 9, last.

In formulating the fundamental rules which will govern the states and the Federal Government in administering the law, the Department of Agriculture is seeking the counsel of the state highway departments as represented by the executive committee of the American Association of State Highway Officials. Members of the committee are: George P. Coleman, State Highway Commissioner of Virginia; Paul D. Sargent, Chief Highway Engineer, Maine; Austin B. Fletcher, State Highway Engineer, California; W. R. Neel, State Highway Engineer, Georgia; Thomas H. MacDonald, Chief of the Bureau of Public Roads; George E. Johnson, Secretary, Department of Public Works, Nebraska; Ira R. Bowning, Member of Highway Commission of Utah; R. J. Windrow, State Highway Engineer, Texas; W. D. Uhler, State Highway Engineer, Pennsylvania, and D. P. Olson, Director, Bureau of Highways, Idaho.

Pending definite decision upon details of the federal highway system, each project submitted by the states will be examined with the utmost care by the Bureau of Public Roads to determine whether it is likely that the roads proposed will come within the Federal system as finally selected. The department regards the approval of this system as of great importance. Each project submitted in advance of the definite decision upon the system as a whole will have an effect in fixing particular routes and so determining the system. Location of the projects, choice of routes, and character of improvements proposed will be given close study.

Each state highway department has been requested to submit as soon as possible to the Department of Agriculture a tentative map showing routes proposed for primary and secondary systems. In examining and passing upon these recommendations special consideration will be given to social and economic questions involved, such as service to population, established trend of traffic, existing industries, natural resources, etc. In considering plans for individual projects special attention will be devoted to grade crossings, gradients, curvature, bridges, general drainage conditions, location of material supplies, etc., but in the selection of the system the broader social and economic principles will govern.

STATE HIGHWAY WORK IN MONTANA

The total value of construction performed by the Montana State Highway Department during he fiscal year 1921 as shown by Chief Engineer Edy's annual report was $3,139,244.31, an amount which exceeds the work of any previous year and lacks but $40,000 of equalling the value of construction work performed during the entire four-year period from 1917 to 1920 inclusive. The maximum value of construction work in any single month was $478,695.19.

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TABLE OF CONTENTS

*Road Work in National Forests. By F. E. Bonner . 81

Would Limit Federal Aid Funds 82

Middle West States Boycott Cement 82

Surface Finish in Concrete Roads. By H. E. Breed . 83

Bituminous Foundations for Pavements. By Hugh W. Skidmore 84

*An Analysis of Present Highway Traffic and a Prediction of Future Highway Traffic. By John H. Mullen 87

Paving Widths for Highways Serving Large Cities. By William E. Cavanaugh 92

Pennsylvania State College Offers Correspondence Courses 93

Much Highway Construction was Completed in December 93

Portland Cement Output in December 94

EDITORIAL:
Tax Exemption on Road Bonds 89

MEETINGS:
Calendar 94

National Highway Traffic Association 94

National Slag Association 94

PERSONAL MENTION 94

*Illustrated Article

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THE HIGHWAY CONTRACTOR AND ROAD BUILDER

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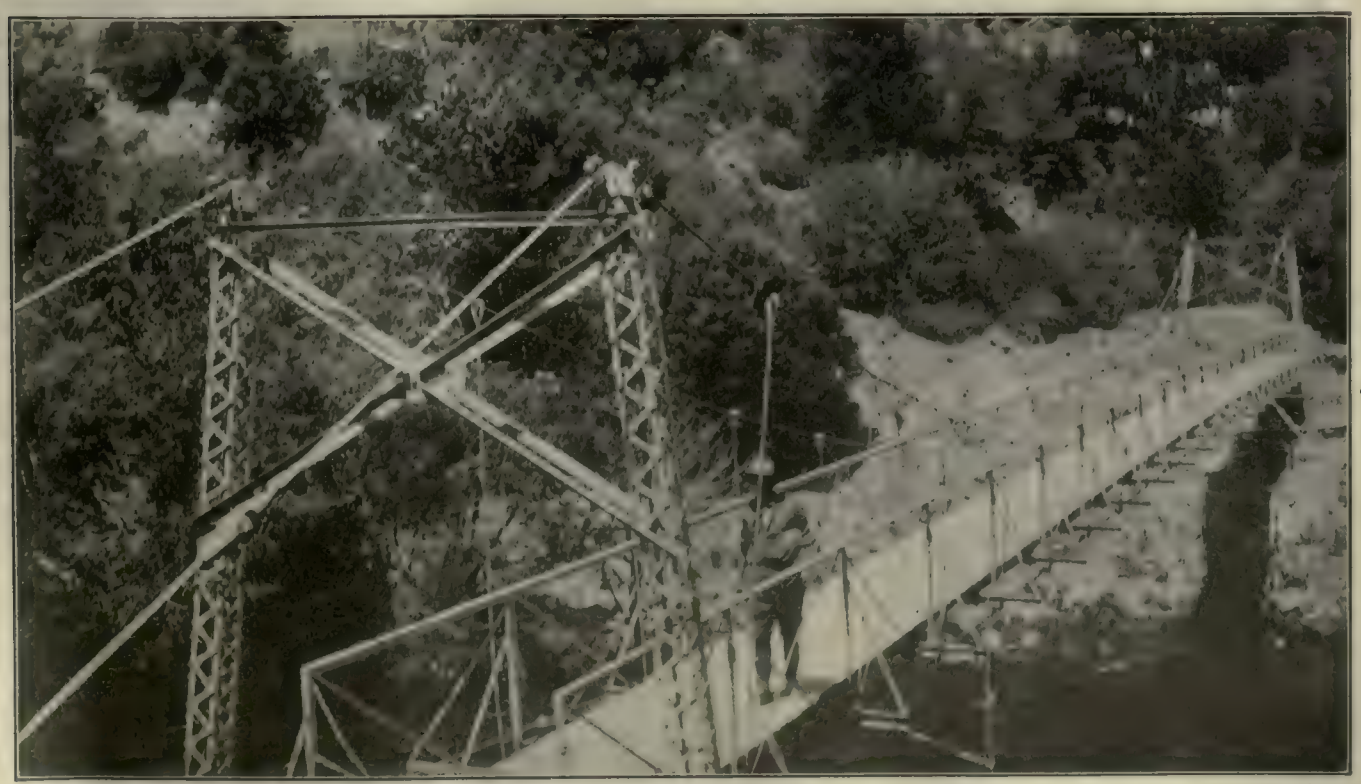
Road Work in National Forests

By F. E. BONNER†

National forests contain a total of more than 156,000,000 acres of land in the ownership of the United States and embrace much of the most rugged, densely timbered and least developed regions of the country. The need of a complete system of roads and trails for the protection, management and development of these vast regions is obvious.

The work of providing an adequate system of roads and trails in the national forests has been progressing steadily since 1905, when the Forest Service became charged with the administration of these regions. Early appropriations were small however, and it was not until recent years that impressive progress has been made upon the work. Appropriations previous to that in the Federal Highway Act of Nov. 9, 1921 consists of $19,000,000 under the acts of 1916 and 1919 and also a provision in an act of 1913 which permitted the Forest Service to use for improvements 10% of the receipts each year from the sale of timber and other forest products. This latter fund has amounted so far to slightly more than $3,000,000. Under the past appropriations there has been expended about $20,000,000 but a great deal of work still remains to be done. According to the best estimates prepared by the Forest Service there are about 5,400 mi. of road still required to complete the state highway systems traversing the national forests or con-

†Acting Chief Engineer, U. S. Forest Service.



STEEL SUSPENSION TYPE TRAIL BRIDGE—SEQUOIA NOTT FOREST, CALIFORNIA

tiguous to them. About 8,500 mi. of roads are needed to complete the county highway systems within the forests. Additional roads required principally for the protection and utilization of the resources of the national forests aggregate more than 13,000 mi. Aside from the roads, the pack trails needed in the national forests, principally in connection with fire protection work, will entail about 40,000 mi. of further construction. The total cost of providing all these transportation facilities will involve an outlay of approximately $140,000,000.

ROAD IN OLYMPIC NATIONAL FOREST

The Secretary of Agriculture has apportioned $15,000,000 among 27 states, Alaska and Porto Rico for the construction of roads and trails in national forests.

Of this sum, $9,500,000 known as the "National Forest Highway Fund" is set aside for roads of primary importance to states, counties and national forest communities; $5,500,000 constituting the "National Forest Development Fund," will be used for the construction of roads and trails needed for the administration and utilization of the forests themselves.

These appropriations will give a new impetus to the work of opening up vast tracts of valuable timber and areas of scenic beauty for the use and enjoyment of the American people.

The development of roads and trails throughout the forests will aid materially in fire protection. At present there are large areas of trackless wilderness within the national forests that can not be reached by trails. When lightning storms sweep over these inaccessible areas, heavy fire losses of public timber often occur.

Speed in reaching a forest fire, is just as important in protecting the country's forests as is speed in city fire protection. But high speed within the forests means four or five miles an hour over a mountain trail. If no trail exists it is often impossible for the fire fighters to average more than one-fourth of a mile in an hour.

In the past, construction of many urgently needed forest roads has been deferred for lack of sufficient funds. Much of this work can now go forward. The Forest Service estimates that eventually over $100,000,000 will be required to supply a thoroughly adequate transportation system throughout the 156,000,000 acres within the national forests.

The distribution by States of the "National Forest Development" and "National Forest Highway Funds" is as follows:

State	Nat'l Forest Highway Fund $9,500,000	Nat'l Forest Development Funds $5,500,000	Totals
Alabama	4,880	5,799	10,679
Alaska	970,271	50,222	1,020,493
Arizona	598,189	280,722	878,911
Arkansas	70,365	72,573	142,938
California	1,460,871	703,822	2,164,693
Colorado	717,058	336,360	1,053,418
Florida	25,118	8,730	33,848
Georgia	13,355	20,347	33,702
Idaho	1,097,894	1,088,656	2,186,550
Maine	2,760	4,754	7,514
Michigan	3,638	6,220	9,858
Minnesota	60,929	65,621	126,550
Montana	878,886	574,615	1,453,501
Nebraska	11,065	11,159	22,224
Nevada	207,984	55,377	263,361
New Hampshire	35,294	24,276	59,570
New Mexico	458,258	219,652	677,910
North Carolina	27,856	46,984	74,840
Oklahoma	5,645	8,764	14,409
Oregon	1,157,109	718,555	1,875,664
Porto Rico	1,454	5,344	6,798
South Carolina	1,572	8,704	10,276
South Dakota	77,553	64,139	141,692
Tennessee	20,896	23,243	44,139
Utah	371,776	164,258	536,034
Virginia	26,140	46,512	72,652
Washington	708,133	602,889	1,311,022
West Virginia	6,051	14,602	20,653
Wyoming	479,000	267,101	746,101
Totals	$9,500,000	$5,500,000	$15,000,000

WOULD LIMIT FEDERAL AID FUNDS

President Harding recently stated to the House Committee of Roads that he favored the limiting of Federal aid appropriations to $75,000,000 per year for the present. It is expected that appropriations of federal aid funds will soon be made so as to be available for the year commencing July 1, 1923.

MIDDLE WEST STATES BOYCOTT CEMENT

Highway officials of the States of Illinois, Michigan, Minnesota, Iowa, Kansas, Wisconsin, South Dakota and Missouri at a recent conference in Chicago, pledged that they would let no further contracts for concrete roads until the cement manufacturers lowered the price of cement.

The Portland Cement Association has opened two new district offices; one at 10 Norh High Street, Boston, Mass., with L. T. Loring in charge; the other is in the Finance Building, Philadelphia, Pa., with D. S. MacBride in charge.

Surface Finish in Concrete Roads*

Has Important Bearing Upon Life of Road—Irregularities in Surface Caused by Non-Uniform Aggregates or Foreign Materials Therein, Poor Workmanship, Cracks and Uneven Joints

By H. ELTINGE BREED†

Apparently a strong mental tendency is to disregard the obvious and seek the remote. Perhaps this is because the obvious is often an aggregation of trifles, while the remote may be striking, stupendous. Certain it is that almost any more obscure cause may be heard given for the success or failure of any road, than the simple one of surface finish. Yet, I believe that in the concrete road economically designed, the life of the pavement depends as much upon the surface finish as upon any other factor.

We know now that impact is the great cause of destruction in our pavements. Impact is the bumping or banging of one object upon another. As I roll a smooth cylinder along a smooth table there is practically no impact, but let ridges appear in the table, and as the cylinder bumps along over them, you get a series of impacts that, if the cylinder be heavy enough and rolled often eough, will soon wear out the surface and damage the structure.

That is analogous to what is happening to our roads If the wheels of vehicles are smooth and the pavement surface is smooth there is no damaging impact from traffic. The road lives even though it be weak in proportion to the volume and weight of traffic it must carry. But let surface irregularities develop, and no matter how strongly built, the whole pavement soon shows the effects of wear. We build our roads on an average to withstand a pressure of 800 lb. per lineal inch width of tire. Yet, if an uneveness in surface of only ¼ in. occurs, the impact of one rear wheel of a 5-ton truck may exert an impact pressure upon the road of 20,000 lb. Under such pressure, the uneveness becomes a depression whose edges spall and break, causing further impacts and more depressions until the pavement is badly damaged.

In order to lessen impact we must get and keep smooth surfaces. How can we do it? Close scrutiny of work and infinite attention to detail are essential. Then there are certain general remedies suggested by the general causes of uneveness, specific remedies being tried by different states or on different jobs, and different methods of work and machinery.

There are five general causes of uneveness in the pavement surface:

1. Foreign materials in the aggregate, which, failing to amalgamate are ousted, leaving holes and depressions.
2. Non-uniform aggregates, which cause inequalities in wearing resistance to traffic, and subsequent depressions in the weaker places.
3. Poor workmanship in striking off and finishing.
4. Cracks, longitudinal and transverse, due to frost action, changes of temperature or unequal bearing power in the subsoil.
5. Uneven joints, perhaps the most common cause of surface trouble, due often to the piling up of joint material or to a difference in elevation of the slab surface.

The general remedies for surface uneveness are as obvious as the uneveness itself, and therefore, perhaps, as often neglected—strict specifications exacting good material and good workmanship. More and more we are getting these on paper. The problem is their application to the job, because there is where the human element enters. Now solve the personal equation between engineer and contractor. I wish that sometime we might have fuller discussion on this point. The answer is at once made that the relationship should be one of cooperation and mutual endeavor toward a common end—the best possible road. But as long as private profit outdistances social welfare as an aim in our economic life, just so long are we often going to have the contractor trying to make him put all he can into it. So sometimes the letter of the specifications is violated, and frequently their spirit. When all engineers know their job so well that they can show contractors easier and better methods of doing their work, and when all contractors regard highway work as a legitimate industry and not a financial gamble, then we shall have that adherence to specifications that will insure good work and smooth surfaces.

Three other general methods of preserving good surface finish once it is obtained are the use of steel reinforcement, the division of the road longitudinally, and the wider spacing of joints with the use of dowels.

The advantages of steel reinforcement are that it gives the road greater bearing power and greater resistance to frost action and that it offsets irregularities and weaknesses in the sub-soil. By helping to preserve the integrity of the pavement, it minimizes any tendency towards cracking, which is of course a cause of surface uneveness.

The division of the road longitudinally increases its beam strength about fourfold. Observation reveals that longitudinal cracks are not found in slabs 9 and 10 ft. wide, though we have all encountered them in slabs beyond that width. The reason for this difference is still conjectural, but until it is ascertained we would do well to be guided by results hitherto obtained, and

*Paper presented at Nineteenth Annual Convention of the American Road Builders' Association, Chicago, Ill., Jan. 16-20.
†Consulting Engineer, New York, N. Y.

build our concrete roads in two longitudinal sections.

Transverse joints being a prolific source of trouble, it is well to diminish their number as far as possible through the use of the longer slab. This wider spacing of joints becomes feasible through the use of steel reinforcement to meet the temperature stresses of the slab. The use of dowels gives stability to the joints and holds the surface even. The submergence of joints an inch below the surface has proven unsatisfactory. Devised at first to secure a smooth surface and permit the rise of a finishing machine, it seemed admirable until subsequent expansion crowded and crushed the concrete above the joint material, leaving a badly ravelled and spalled joint. The best method that I have found of making a joint is to submerge the joint material until after the screed or finishing machine has passed over it; then to lift the joint material slightly above the surface with long fingered tongs; then, to finish the joint with the split float or split roller, rounding the concrete next to the joint material with an edging tool.

Specific application of these general principles is found in the requirements of such states as Delaware, Pennsylvania and New York. In these states, and in others, the specifications exact good workmanship by allowing a maximum of only ¼ in. depression in 10 ft of pavement tested with a straight edge. The use of the straight edge on green concrete indicates depressions to be rectified and insures good results. These states specify materials with such precision as almost certainly to preclude the use of foreign materials in the aggregate or of non-uniform aggregates. They design the roads so as to minimize the danger of movement in the slab and resulting cracks, and they give special attention to the placing of joints and to the suitability of the machinery in use.

All of these precautions were taken on the road built last summer in Old Bennington, Vt., by the Fred T. Lay Company, and so far not the slightest indication of any surface uneveness has appeared on it. This tends to support my belief that we are going to be able to build roads within necessary financial limits that under the traffic permitted by law will be practically indestructible.

The actual method of finishing is of course important in securing a smooth surface. Some road builders prefer to use the finishing machine with the roller and belt. It is essential that the roller be light. A too heavy roller pushes the crown out of the pavement, and spoils the surface. Most specifications call for a weight of from 12 to 15 lb. per foot length. Some builders omit the roller, using only the machine. My own experience indicates that the roller helps. One advantage of the finishing machine is that a dryer concrete can be used with it which gives greater strength to the pavement. It also gives more uniform results than can be obtained with a green gang, and seems in general more fool-proof than the hand method. Still many prefer to strike off with the hand screed using the roller and belt. This has the advantage of making one piece of plant the less to get out of order and where a heavy screed is used in the hands of competent workmen it gives as smooth a finish as the finishing machine.

With either method the board belt gives unquestionably the best finish. The bow belt however can give good results. Proper belting takes off not only the excess water, but also the clay loam, laitance, etc., that to form a scale on the surface.

I have tried in this paper to bring to your attention only the salient features in securing surface smoothness in the hope that a hasty summary might help to bring practice and theory closer together so that theory might receive fresh impetus to discover the something new on the subject that I have not been able to find and tell you.

Bituminous Foundations for Pavements*

By HUGH W. SKIDMORE†

The two most important elements affecting the design of pavements for both city streets and county roads are the character and the intensity of the traffic to be carried. These two factors combine to determine the probable destructiveness of the most potent of all traffic forces—impact. There are other important considerations, such as bearing power of soil, temperature variations, drainage, quality and quantity of local materials, etc., but all of these are of secondary consideration when compared with traffic. The remarkable changes in kind, weight and speed of vehicles which have occurred in the last few years, have necessitated departures not only from some of the accepted practice formulae pertaining to various pavement types; but also from some of the previously conceded standard types of foundation and wearing surface construction.

It is ridiculous to assume that any one type of foundation or wearing surface will prove the best under all conditions. In fact, it is often the case that more than one basic design should be used within a given length of pavement and until this fact is more generally recognized, failures will continue to be more prevalent than they should by reason of the known limitations attending any given basic design.

Two schools of thought, as applied to pavement

*Paper presented at Nineteenth Annual Convention of the American Road Builders' Association.

†Chicago Paving Laboratory, Chicago, Ill.

foundations, have been evolved. These are essentially different in their fundamental principles. One of them seeks to overcome the destructive effect of the traffic loading, which at any instant may be converted into impact of variable intensity and often equivalent to several times the dead load by means of a rigid slab possessing strength superior to the possible force of impact; the other dissipating the blow by absorbing a very considerable portion thereof through a flexible structure, which is always in actual contact with the subgrade, thereby insuring greater uniformity of load distribution and functioning as a distributing medium or foundation and not as a deflector.

Rigid Types Discussed

Rigid types, since they must possess strength superior to the traffic forces, have undergone in rapid succession modifications which, with few exceptions, have been of such nature as to increase the original cost of the pavement very substantially. Perhaps the most important reason underlying the necessity of these modifications is the fact that the rigid slab is not at all times in actual contact with the subgrade and, therefore, does not always function as a distributing medium, but must sustain the entire force of the loading within itself. The fact that concrete pavements warp due to temperature stresses, which has been demonstrated by certain investigations of the Illinois State Highway Department, indicates that at almost any time the rigid slab can be expected to be functioning either as an arch, with bearing at the outside edges of the slab and free from the subgrade in the central portion—or functioning as a simple cantilever beam, with the fulcrum at or near the crown, and with the outside edges not in contact with the subgrade; therefore, the maximum strength of the rigid pavement slab will be demanded when it is acting as a cantilever beam. In view of the data thus far obtained, it is only logical that this idea has been introduced into the design of rigid pavements. It is well known that the internal stresses in pavements, created by changes in temperature, oftentimes become very powerful forces and to date the rigid type of construction has failed to offer uniformly satisfactory resistance, as evidenced by cracking.

While it is true that the seriousness of such failures is often reduced by more careful attention to drainage, preparation of subgrade, etc., they are, nevertheless, admittedly inherent weaknesses in this particular type. Soil conditions in certain sections of the country may be such that during a portion of the year the bearing power of the soil will be so low that it cannot be relied upon as offering any very substantial support to the pavement structure. The unstable soil condition may be of limited extent and the soil may be of such character as to admit of ready drainage so that proper attention to this feature will remove the difficulty. Again, unstable soil during a considerable portion of the year may prevail more or less generally throughout certain localities, or the soil may be of such nature that it is practically impossible to adequately drain it even with very elaborate structures. In such cases the construction of sub-foundations may prove a practical solution, while at other times it will be found that a rigid pavement structure will be the most economical. Likewise often a combination of subgrade drainage and the construction of artificial subgrade or sub-foundation overlaid by either a rigid or a flexible type of structure will prove to be the most adequate solution.

It is quite natural that concrete and monolithic brick and block pavements, which exemplify rigid construction types, should be passing through the experimental stage in order that they can be studied with respect to their probable ultimate efficiency. Ultimate efficiency, or economy, is of supreme importance and must include not only the original cost, but to this must be added the cost of maintenance and the total spread over a term of years representing the average natural life of the pavement.

Only quite recently have we come into possession of any very definite understanding of some of the forces to which pavements are subjected and as to what limitations appertain to various types with respect to their resistance to such forces. There remains a vast amount of information still to be acquired and investigations which are now in progress will undoubtedly indicate new channels for further study. Some of these investigations now under way deal exclusively with either the rigid or flexible type, while others include both. It has recently been my privilege to observe the work of this nature which is being conducted by the Illinois State Highway Department and to note the very commendable thoroughness with which they are attacking many of the problems surrounding several designs of modern highway construction. There is no doubt but what a fund of very valuable data will result from such impartial, scientific investigations, some of which will apply to all types of pavement construction while some will apply to only such types as are actually under investigation. It is hoped that as results are published from time to time and the possibilities of further investigation concerning either flexible or rigid types are indicated, that such studies will be immediately undertaken and that this practice will continue until all of the fundamentals underlying both the rigid and flexible types have been determined, and it will then be possible to design pavements with a thorough understanding of the limitations and the adaptability attending the use of both.

Flexible Types Discussed

Flexible and semi-flexible pavement structures are the oldest types known, and we have only to picture the old Roman roads to realize that the soundness of such construction was thoroughly demonstrated

long ago. Although modern traffic requires a wearing surface of superior quality, it is debatable whether highways as they are so often built in this country today will ever prove as truly economical as they would if we employed more generally the old idea of a built-up roadbed, and then laid upon this our modern traffic floor.

Flexible foundations include gravel, broken stone, waterbound macadam, bituminous macadam, and hot-mix bituminous concrete. They are usually classified as to value in a pavement structure in reverse of the order named, with bituminous concrete as the highest type. It is estimated that there are 15,000,000 sq. yd. of "black base" giving satisfactory service in this country.

The bituminous foundation structure, although possessing considerable beam strength, functions primarily as a shock reducer, that is, it gives slightly under the blow of impact in transmitting the load to the subgrade. Therefore, the design of this type places considerable reliance in the load supporting power of the subgrade. Its use then is dependent upon a knowledge of the ability of the subgrade to support loads equal to the probable force of impact reduced by the slab strength residing in the bituminous structure; whereas the rigid type, regardless of the bearing power of the soil, must be built to sustain the entire force of impact. For this reason a much thicker rigid foundation is required under given traffic and subgrade conditions, as has been demonstrated by impact tests.

It will be readily seen that even where soils are of questionable value as a subgrade, bituminous foundations may still be employed economically, if an artificial subgrade of broken stone, gravel, boulders, or even cheaper materials, is first constructed. When old macadam or gravel roads already exist, an excellent artificial subgrade is offered at almost negligible cost. If widening is necessary, this can usually be accomplished as in the case of the Kingston Pike at Knoxville, Tenn., where "black base" was laid about 4 in. thick over the old macadam and 7 in. thick at the edges of the widened pavement.

In the West, where the most extensive yardage of bituminous foundation has been laid, the general practice seems to be in taking alternate bids to specify 5 in. total depth for "black base" pavement and 7 in. for concrete pavement of 1:2:3 mix. Almost universally bids for "black base" pavements have been less than for either concrete pavement or asphalt wearing surface on concrete base. The saving has varied from 20 to 60 ct. per square yard.

Contractors' Views

The opinions of contractors are always necessary and valuable since the very nature of their business requires that they give very careful thought to cost and practical construction features. With this idea in mind I have taken advantage of every opportunity to discuss with them construction problems and costs. In order to obtain an even more representative idea of their experiences and views regarding bituminous base, questionnaires were sent to well known concerns throughout the country. Both the number of replies and valuable data contained in them greatly exceeded expectations. The combined activities of the contractors who replied cover every state of the Union as well as parts of Canada, and therefore, can be safely considered as representing the general attitude.

Briefly, the experience of contractors is such that they are willing to guarantee "black base" as readily as concrete, and with few exceptions, stated that less risk was attached to "black base." The experience of contractors generally has been decidedly lower maintenance expense, and lower first cost except in a very few instances where freight rates proved to be an extraordinary item. Assuming equal depth of foundation, the use of same aggregate materials in both types, and concrete not to exceed 1:2:5 in richness of mixture, 90% estimated a difference in initial cost of from nothing to 50 ct. per square yard less for "black base" and 75% estimated "black base" at from 25 to 50 cents per square yard less than Portland cement concrete. Since it is true that under similar traffic and subgrade conditions, less depth of "black base" is required, it will be readily seen that rigid foundations will usually cost substantially more than the highest type of flexible base.

One contractor said that during the past 14 years, 85% of the pavements he has laid have been upon flexible foundations, including broken stone, macadam and a goodly yardage of "black base." Certainly this contractor's experience with this type of foundation has proven highly satisfactory.

The only objection raised to "black base" construction by any of the contractors was the possibility of idle equipment in the event a protracted rainy season was encountered on work where the subgrade did not drain readily. Undoubtedly such a combination of circumstances would delay almost any kind of paving construction. However, it is quite probable that it would prove more serious with bituminous work than in the case of rigid base. If it is known that such local conditions as these are at all probable, it would seem that the engineer would provide for such a contingency by specifying an alternative.

Conclusion

In summing up the advantages of bituminous concrete foundation it is thought that some of those referred to in previous discussions will bear repetition:

1. Because of greater resistance to impact, permits the use of a thinner base course than is required of the rigid types.

2. Provides uniform contact with the subgrade, thus insuring greater uniformity of load distribution, and precluding the necessity of relying upon the pavement

structure to sustain the entire force of the traffic loading.

3. Provides homogeneity of mass and positive bond between wearing course and foundation when bituminous top course is employed.

4. Provides freedom from cracks, upheavals, and ruptures which are common to rigid types.

5. Insures against the presence of moisture in the foundation structure, thus prolonging the life of the pavement.

6. Does away with the long period of time required for the curing of concrete, thus permitting the opening of completed work to traffic immediately and providing a greater rapidity of turnover to the contractor.

7. Permits the use of the same aggregate materials as are ordinarily employed in concrete foundations, and provides decided construction economies.

8. Under given conditions costs substantially less than rigid construction.

9. Maintenance expense is less than for rigid pavements.

10. May be easily repaired at minimum cost, the surface patch method being applicable except in the case of very serious defects.

An Analysis of Present Highway Traffic and a Prediction of Future Highway Traffic*

By JOHN H. MULLEN†

The study of highway traffic has been made necessary by the tremendous increase in the use of motor vehicles in this country. Within less than 15 years a complete revolution of highway transportation has taken place, changing within that period from horse drawn to almost entirely motor driven traffic.

Horse drawn traffic is still an element to be considered.

On account of the small percentage of horse drawn vehicles we are now inclined to eliminate them from consideration as a governing factor in traffic studies, but as an obstacle to speed and consequently as a limitation on the volume which may be carried over a congested line this traffic is of importance and calls for thought on the part of highway engineers, to provide some relief such as slow traffic lanes along the sides of heavy traffic roads. Most of the road pavements in this country have been built 16 to 18 feet wide and generally without shoulders adequate to carry a line of slow moving traffic. When one of these roads carrying a small number of horse drawn vehicles acquires a traffic of over 1,500 vehicles per day there is congestion, decrease of speed and danger of collision on account of difficulty in passing. The decrease in horse drawn as a percentage of the total traffic has been very rapid, but this does not mean that the volume of horse drawn traffic has decreased in like proportion. To the contrary on many main roads it has remained practically constant and in some instances has increased. As a typical example, on one of the main roads in Minnesota the average daily traffic count for the four past years shows the following number of horse drawn vehicles in successive years, 17, 33, 35 and 38 per day, a reasonably constant number, while the same road for the same years showed motor vehicles to the number of 440, 501, 883 and 1,230 respectively. This situation would not exist on roads connecting contiguous industrial centers but will be found to be fairly general in agricultural communities, particularly where farms are small and horses are required for other farm work. In other words, throughout the United States, horse drawn traffic will have to be reckoned with as a minor element in highway transportation for many years.

The remarkable increase in the number of motor vehicles in use in this country, has brought many benefits. As a business proposition, the motor vehicle has increased the trade radius of the merchants and has made possible dairying and crops requiring quick marketing on great areas of land which could formerly be utilized only for grains and staple crops. It has also made possible the de-centralization of smaller industries formerly confined to restricted districts on account of slow trucking, but which now are enabled to locate in suburban territory. It is predicted that with the improvement of roads this latter condition will be developed to an extent that will greatly improve the living conditions of industrial workers.

The motor vehicle is revolutionizing the social life of the country. Formerly the general travel radius on roads did not exceed ten miles and the visiting radius in the rural districts was two or three miles. The trip to town was often a weekly affair taking a whole uncomfortable day. Rarely was there any visiting between towns or to different parts of the country excepting on railroad excursions. But with the advent of the motor vehicle the travel radius on highways has been greatly extended and is now limited only to the condition of the roads. We find in the lake regions of Minnesota during the summer, cars from nearly every state in the Union; the census at 137 stations in the State during 1921 showing an average daily traffic of 565 cars of which 59 or more than 10 per cent were from other states. It is reasonable to assume that not less than another 25 per cent. were from other counties within the State, which at

*Paper presented at the annual meeting of the American Association of State Highway Officials, Omaha, Neb., Dec. 5-8, 1921.

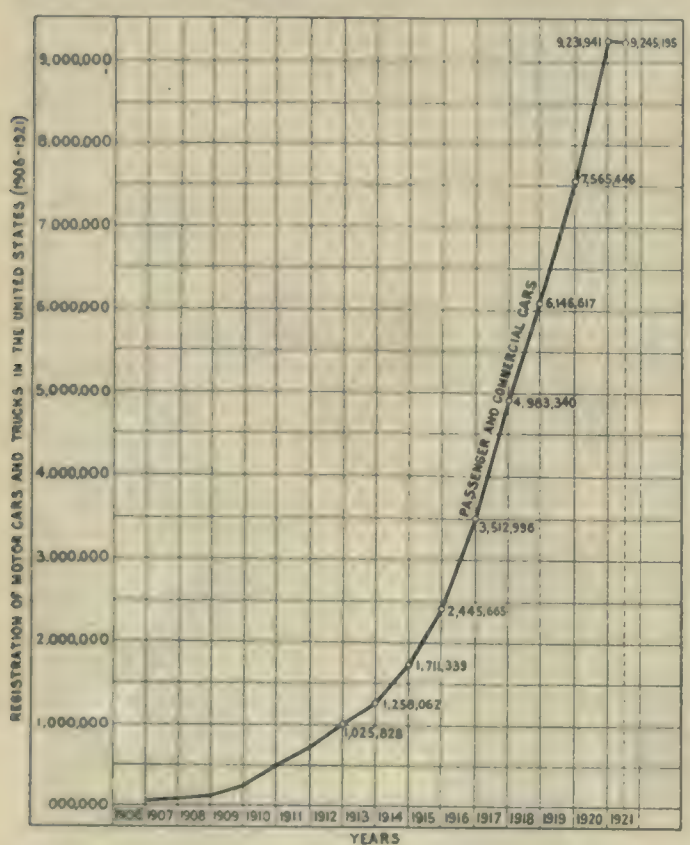
†Chief Engineer, Minnesota Highway Department.

an average of three people per car meant at least 600 outside visitors per day passing each recording station. Practically every farmer now has an automobile and in the rural districts of the middle west there are farmers' clubs in nearly every township, made possible by their ability to attend evening meetings without discomfort. The trip to town is now a relaxation of an hour or two and the farmer's family makes several drives a week to attend the movies or other diversions in neighboring towns.

One of the greatest benefits is through the consolidation of rural school districts made possible by motor transportation, which is giving to the farm children throughout the country the advantage of graded schools without having to move to the cities. All of this is giving us a broader view of life and creating better general conditions, but at the same time is increasing traffic on the highways, which requires extensive programs of road construction and maintenance.

Increase in Number of Automobiles Per Capita

From such records as are obtainable, it appears that the increase in motor traffic is very nearly in the ratio of increase of motor vehicle registration. This increase in the United States, as shown on the chart, follows a rapidly rising curve, starting at 48,000



vehicles in 1906, running to 500,000 in 1910 and 2,445,665 in 1915. From 1915 to 1920 the increase is practically uniform at the rate of about 1,300,000 vehicles per year, with a total registration January 1, 1920 of 7,565,446. During 1920 there was an increase of 1,666,495 vehicles, making a total registration on January 1, 1921 of 9,231,941. Registration for the first six months of 1921, as reported in "Public Roads" is 9,245,195—which would indicate a considerable falling off in the ratio of increase of cars this year. This is to be expected, for it is estimated that the number of cars in proportion to population is approaching a reasonable maximum. In the United States there were 42 persons per car in 1915, 14 per car in 1919, and 11 persons per car in 1920. The 1920 figures range from a maximum of 31 persons per car in one of the southern states, to 5 and 6 in well developed agricultural sections; with 12 to 14 persons per car in the industrial sections where roads are practically all improved. It may safely be predicted that the number of automobiles will not exceed one to five people in the agricultural sections and one to ten people in the industrial sections of the country, even under the most prosperous conditions, with the probability that there may be a falling off in ratio during times of depression, for it must be admitted that prosperity has a considerable bearing upon the number of passenger cars in the country.

Commercial Traffic Presents Most Difficult Problem

Seasonal variation in traffic as shown by records would indicate that probably 25 to 35 per cent. of that on the main lines is regular and may be classed as business or necessary traffic. This traffic will continue to use the existing main lines and would not be diverted by improvement of parallel roads, but the balance, which may be classed as convenience or pleasure traffic will in part seek other routes when the main lines become congested. This leads one to believe that a considerable portion of the traffic will be taken care of by parallel roads, and excepting for suburban roads and routes physically confined to one line between centers, the volume will not greatly increase on the present heavily travelled roads, but will be spread more uniformly over parallel routes.

Commercial traffic, including trucks and passenger busses presents the most difficult problem for solution by the highway official. This class of traffic has had a marvelous development within a very few years, but this development cannot be accurately estimated for the reason that many of the States do not have a separate registration for trucks, and traffic counts are scattering and not uniform enough for tabulation. It is estimated that there were approximately 988,000 trucks and commercial cars registered for the year 1920, or slightly over ten per cent. of the total motor vehicles. It is evident from observation and traffic counts that trucks are confined more to cities and do not use the rural highways in proportion that automobiles do except in industrial sections, but it is also very evident that the ratio of increase in the number using the roads is greater than for automobiles. For example, traffic counts taken at the same stations on State roads in Minnesota show daily averages for 1917

(Continued on Page 90.)

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

Founded January, 1892

E. L. POWERS
Editor

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Articles by road builders are solicited. They should be short and, if possible, accompanied by photographs. Those accepted will be paid for at current rates.

Volume LXII. February 8, 1922 Number 6

TAX EXEMPTION ON ROAD BONDS

The McFadden resolution recently introduced in the House, proposing a constitutional amendment abolishing tax exemption on Federal, state and local public works securities, would seriously interfere with road construction in the various states if adopted. This measure is sponsored by Secretary of the Treasury Mellon and extensive favorable propaganda for it is being carried on by the daily press. Accordingly, there is a growing disfavor on the part of the public toward tax exempt public works securities. As far as we are informed, road builders have not yet taken cognizance of this proposed legislation. While a number of resolutions of more or less importance were adopted at the recent convention of the American Road Builders' Association at Chicago, it is to be regretted that this important matter was overlooked.

In urging the adoption of this amendment to the constitution, Representative McFadden said: "The issuance of tax exempt securities by the Government, the states and their political subdivisions makes possible the creation of two classes—the wealthy, free from the burdens of taxation, and the workers, who are forced to bear the burden of which the wealthy are relieved. If the issuance of tax exempt securities is allowed to continue, a social upheaval will occur which may be so far-reaching in its effect as to undermine our constitutional Government. It has been estimated that approximately $15,000,000,000 of tax-exempt securities have been issued by the Government, states and political subdivisions. Of this about half represents the debt of states, cities, school districts and other political subdivisions, while the balance represents the obligations of the Government."

It is the popular thought that tax exempt road bonds are gobbled up as fast as they can be issued, but the fact is that during the past two years, states and counties have had considerable difficulty in marketing their bonds. California, Michigan, Ohio and other states were obliged to raise their interest rates on road bonds to attract buyers. In the case of many counties, road work was seriously hampered because of inability to market bonds. For example, St. Louis County, Missouri, in 1921 received a bid of 88.60 on an issue of road bonds, but was unable to sell them because the state laws prohibit the selling of road bonds at less than 95.

During the past two years road bonds have been marketed only with great difficulty and although the market is now greatly improved, the abolition of tax exemption on these securities would render them very difficult to market even under normal conditions. For example, the State of Illinois has been holding $60,000,000 of road bonds for several years, awaiting a more favorable market. If these bonds are made taxable, when will they be able to sell them?

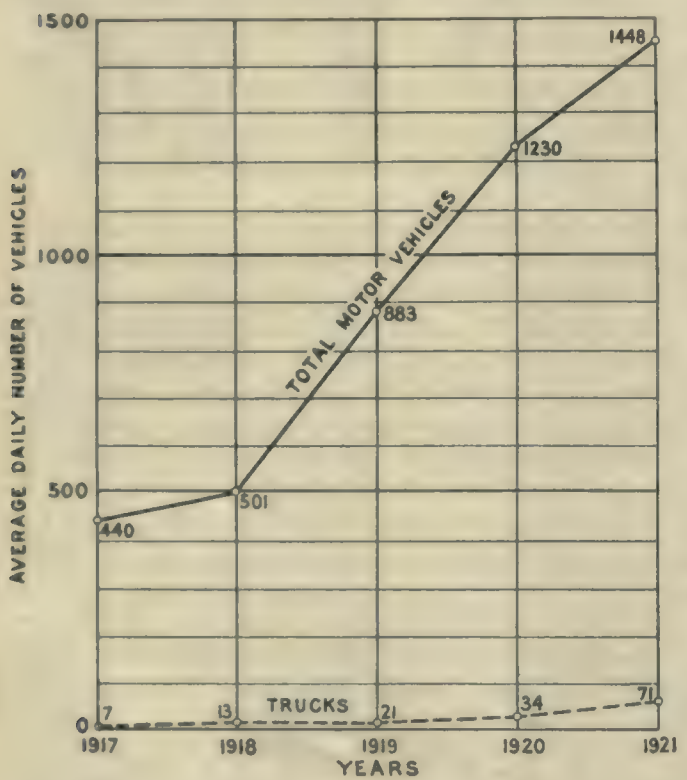
It may appear to some that there need be little apprehension that this constitutional amendment will be adopted. Yet it must be remembered that a decade ago national prohibition was thought by most persons to be next to impossible. With the thousands of small income tax payers in this country lined up against the relatively few who can evade their taxes by investing in tax exempt securities, what will be the result? Public opinion is a powerful force and there is no doubt but that there is a growing disfavor against the tax evader who has invested in exempt bonds.

The rich man ought not be able to evade his income tax by investing in exempt bonds, while thousands of hard working men pay a considerable part of their incomes to the Government. Yet, in our opinion, the unqualified taxing of public works securities is not the solution of the problem, for it would inflict too great hardships upon the financing of roads and other public improvements. Road work would be very seriously hampered if it were necessary for states and counties to market their securities on a competitive basis in the open market. Would it not be better to let public works securities remain tax exempt and limit the amount of exemption for any one individual? Thus, by such an arrangement the value of tax exemption as an aid to states and their political subdivisions in marketing their bonds wold be preserved and the possibility of any person investing all his money in exempt bonds to exade his income tax would be eliminated.

AN ANALYSIS OF PRESENT HIGHWAY TRAFFIC AND A PREDICTION OF FUTURE HIGHWAY TRAFFIC

(Continued from Page 88.)

of 463 automobiles and 8 trucks, while for 1921 the average is 1099 automobiles and 72 trucks. Reduced to percentage the increase in autos is 235 per cent. while the increase in trucks is 900 per cent. These figures are taken on roads which were not substantially changed as to surface and the increase is not due to paving or other influence than the development of trucking. Professor Blanchard is authority for the statement that practically the same situation exists



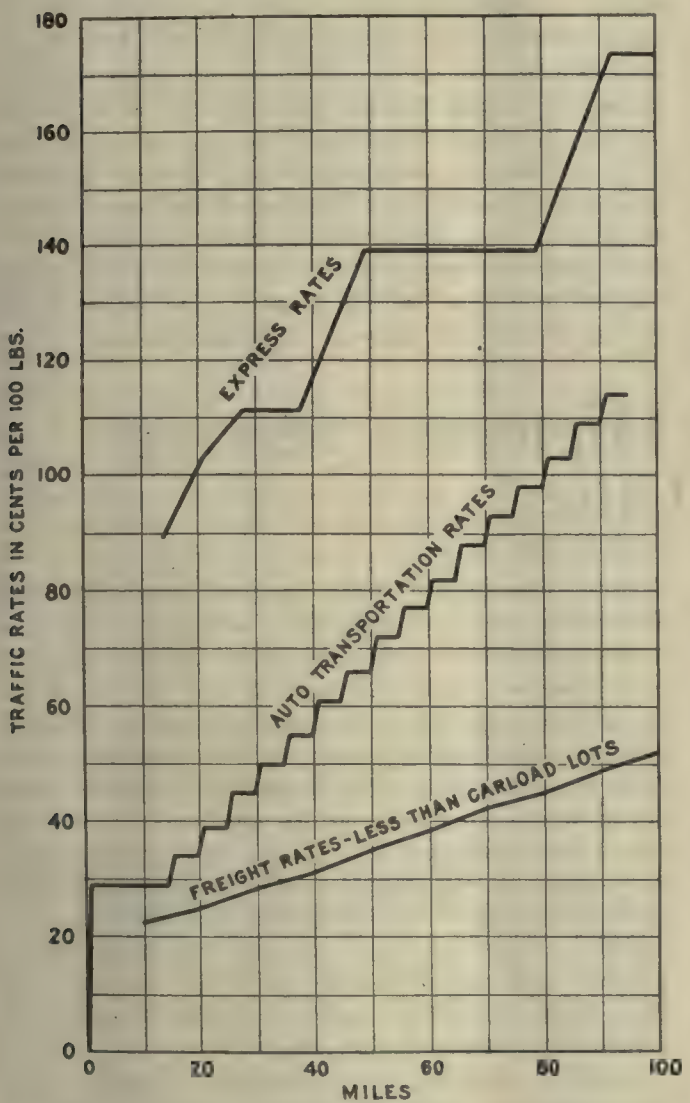
in the Eastern states but of course in much greater volume, and cites hard surface roads in Rhode Island upon which automobile traffic increased 102 per cent. in the past six years while the truck traffic increased 659 per cent. The percentage of trucks to total traffic is also comparable in both of these cases, in Minnesota the increase being from 1¾ to 6½ per cent. in five years, and in Rhode Island from 3 to 15 per cent. in six years. An abstract from the traffic counts made throughout the country, indicates that practically the same ratio of increase prevails, and that the ratio of trucks to cars comes within the range of percentages above stated, which is an indication that we should figure the main arterial higways to carry truck traffic in the amount of about 10 per cent. of the total, running up to 20 per cent. or better on main arteries connecting centers within 50 miles of each other, and not less than 5 per cent. on what might be termed passenger trails.

Observation on the kinds of truck traffic are interesting, and contrary to the general impression we find that the heavy truck is very much in the minority and with the usual exception of roads connecting neighboring cities, the 5-ton truck does not average more than 10 per cent. of the total truck traffic, while 75 per cent. of the trucks are 2 tons and less. It is to be expected that truck routes up to 50 miles in length will have an increasing number of 5-ton or larger trucks, but up to the present time and in the near future the bulk of the truck traffic is what may be termed express rather than freight and can be hauled more economically in the lighter trucks. Furthermore, one of the considerations in selecting truck service in preference to railroad service is speed and the convenience in the pick-up and distribution of loads, which are points in favor of the lighter truck. A bulletin was recently issued by the Department of Agriculture dealing with motor trucks on farms, in which it is stated that on a survey of 753 farms in the eastern states it is found that the farmers own trucks of all sizes ranging from one-half to 5-ton capacity, but that nearly half of the trucks used on farms are of the one-ton size with only 3 per cent. of the owners recommending trucks of over 2-ton capacity. The same condition is found to exist in the middle west where farmers at a considerable distance from railroad stations are using trucks quite extensively and in practically all cases are selecting 2-ton trucks or smaller on pneumatic tires. The extent to which this traffic may grow is dependent almost entirely upon the improvement and systematic maintenance of roads, for a steady traffic or 20 trucks per day regardless of weather conditions, is more injurious to an earth or gravel road than automobile traffic averaging 300 cars per day.

Commercial Trucking

Commercial trucking of commodities outside of cities has developed somewhat blindly and it is found that this service has not been generally profitable to the truck owner except where the entire length of the route traversed is hard surfaced. As an example, a terminal truck service was established three years ago at the Twin Cities in Minnesota and in the second year 25 companies were operating through this agency over all kinds of roads. Of this number, seven have discontinued business on account of poor sections of road on their routes, the remaining eighteen companies are continuing to do business in a more or less profitable way dependent upon the proportion of good roads on the lines they cover. This service has been conducted practically the same as railroad service with regular tariff sheets for the various lines and with cargo insurance in all cases. An attempt was made to operate trucks on a time schedule but this was found practically impossible on account of weather conditions and unfinished sections of road which prevented hauling at certain times. The interesting feature to engineers

in analyzing this service is that the trucking companies find two and three ton units on pneumatic tires to be the economical size. A chart of the rates as compared with first class freight rates for less than carload lots and first class express rates shows that the auto tranportation rates while about 100 per cent. above the freight rate is only 50 per cent. of the express on the short haul but for the longer haul the ratio of difference between freight and auto increases and between auto and express decreases, showing that the unrestricted use of public highways for commercial trucking works very much to the disadvantage of railroad express business for distances up to about 100 miles. For short haul freight, when taking into account the terminal trucking, the auto transportation will relieve the railroads of what they have always claimed to be an unprofitable business and this at a decreased cost to the public. In this connection it is interesting to note the reported statement of officials of a railroad company in New England that the railroad loses one million dollars a year in freight revenues on the shoe industry alone as a direct result of motor truck competition and that some of the small branch lines in the industrial sections of New England have been abandoned by reason of their inability to meet motor truck competition.



Motor Bus Service

So far as traffic is concerned motor bus service may be included as trucking, for most of the busses are 1½- and 2-ton high speed trucks. This bus service is becoming quite general throughout the country and is conducted profitably during favorable weather at rates slightly less than railroad passenger rates. We find, however, that there is a decided falling off in the motor passenger business during bad weather and in winter. Continuous bus service is only established on long sections of surfaced roads, and with the paving or even gravelling of connecting lines of travel we may expect a substantial development of this traffic with its consequent effect upon the railroad passenger business.

It is very evident that in fairness to the tax-paying public and the railroads there must be a State supervision of commercial use of the highways, and that taxes on gross earnings should be imposed for this privilege, or at least that more equitable motor vehicle taxes be fixed for such use of the roads with all revenue made available for road purposes. It is only reasonable that commercial traffic should carry its share of road expense and that the State should prohibit the commercial hauling of passengers or commodities on public highways except by reasonable concerns bonded and supervised by the State.

Study and Regulation of Traffic Necessary.

As stated with reference to horse drawn traffic, the volume which a given road may carry is governed very largely by the manner in which traffic is handled. Practically all State laws now prescribe a maximum speed limit of 25 miles per hour with no reference to minimum speed. To properly handle traffic the maximum on heavy passenger lines should be increased to 40 miles per hour for certain hours of the day with a requirement that traffic must stop on the intersecting lines before crossing or entering the main line, and there should be a minimum speed limit on main lines of 25 miles per hour during these hours. It will be found that roads which now appear to be congested will very easily handle their traffic within these limits, and there is no reason why the minimum rate of speed should not be imposed for at least a 12-hour period from about 8 in the morning until the same hour in the evening. This will take care of the peak load of passenger and light express business and will cause the slow heavy trucking to be handled during the night when there will not be interference on either side. This and other effective traffic regulation calls for a State system of traffic police, the value and efficiency of which has been well demonstrated in the State of Pennsylvania.

Highway engineers and most truck manufacturers

are practically agreed upon an economical limit of weight of vehicles and wheel loads for public highways. This is expressed in the proposed uniform traffic law adopted by the American Association of State Highway Officials and which has been incorporated in the highway laws of several of the States, but in all localities we find an occasional trucking company or truck manufacturer using excessively heavy vehicles. If this were allowed to continue the public would be called upon for an unwarranted expense to rebuild roads destroyed by that small portion of traffic and it is therefore extremely important that a uniform limit be established throughout all of the States and this limit should be well within the maximum prescribed in the proposed traffic law.

In making a study of highway traffic one is impressed by the lack of definite comprehensive information on the subject and the conclusion is that in every highway department there should be an engineer assigned to traffic surveys. These surveys should be made in a somewhat uniform manner in all of the States and the results compiled for the whole country by the Bureau of Public Roads. The highway departments are not organized primarily for the purpose of moving dirt and building pavements, but in performing their real function in the development of the country they are in fact great traffic departments designed to provide means of carrying the tremendous volume of highway transportation and to properly do this work the systematic study of highway traffic is essential.

Paving Widths for Highways Serving Large Cities*

By WILLIAM F. CAVANAUGH†

According to the government census of 1920, we have in the United States today 12 cities with a population in excess of 500,000 people and 56 with a population between 100,000 and 500,000.

A large percentage of the more heavily populated cities today have hard surfaced highways radiating outward from their corporate limits that are entirely inadequate to handle traffic because of their narrowness.

This is not due to a lack of foresight in most cases on the part of highway engineers, but due mainly to the fact that these communities are not in a position to finance the building of a highway to a greater width.

In choosing the proper width to construct a new highway or to widen an old one, it is sometimes quite difficult to determine what width is proper. We have to consider first of all the amount of traffic it takes before construction together with the expected increase it will afterwards be called upon to take. It may be that in succeeding years adjacent and parallel highways will be built and a certain portion of traffic will be diverted over them.

In starting construction at the limits of a city that part of the highway through the outlying districts often requires a greater width than that further on, due to a greater traffic on account of conditions being similar to city conditions and being more heavily populated than portions of the highway further on.

In these communities it is well to take the future growth or expansion of the city into account and plan accordingly, adopting the proper alignment and grades so as to afterwards conform to the grades and alignment of future intersecting streets. Drainage structure should also be planned with this end in view.

In the event that a highway is to be paved twenty feet wide with the intention of later increasing this width it is well to construct the 20-ft. width to conform to the center line of the right of way and not make the mistake that some communities have in building along the old roadbed which deflected here and there from the center line. The main idea of course in so doing was to cut down on the grading cost and obtain a more solid foundation. Afterwards when these territories build up and the traffic increases it becomes necessary to widen the roadbed and it cannot be uniformly widened on each side and the result is the proper crown cannot be obtained on the new road and there is not a uniform sidewalk space. Additional right of way has to be purchased.

An 18 or 20-ft. highway is especially hazardous for pedestrians at night time where highways close to the city are not illuminated. Most states have regulations regarding automobile headlights but the lack of illumination has been the cause of a great many accidents where autoists have run into and injured or killed pedestrians. We have some of our highway in Milwaukee County illuminated and expect to continue this work each year. We are using ornamental-concrete poles with the bracket light and the cables laid underground. Unless these lights are elevated to a height of at least 25 feet there is a very noticeable glare on the eyes of the passing motorist.

Most of our 16-ft. roads today are inadequate especially so when there is any amount of truck traffic and the major portion of our highways are being constructed 18 to 20 ft. wide. This width suffices to care for two lines of traffic. Some consideration should be given to the matter of constructing a 30 ft. width which does not provide for more than three lines of traffic. We often speed up to pass the car in front and doing so may frequently meet another driver doing the

*Paper presented at Nineteenth Annual Convention of the American Road Builders' Association.

†County Highway Commissioner, Milwaukee County, Wisconsin.

same thing coming towards us and the result is a head-on collision in the center. It almost seems that in providing increased widths we should provide for either two, four or six lines of traffic.

I believe the use of a curb is warranted on wider roadways as the fills do not have to be constructed as wide and the shoulder width can be cut down especially through the cuts, doing away with ditching; the drainage structures do not have to be built as wide and less right of way is necessary. It is clearly not good engineering to provide either inadequate or extravagant widths and it is often the case that a pavement 3 or 4 ft. narrower than the one laid would serve all the purposes of the wider one or an additional 3 or 4 ft. to a pavement along a highway especially with a car line will provide for two extra lines of traffic. Pavements are expensive to lay and should therefore be only sufficient to provide for traffic needs during the life of the surfacing.

The blind acceptance of right of way widths irrespective of the various uses to which streets are being put is especially unwarranted in the outlying parts of the city where houses are just beginning to be built and where the widening of main lines of travel would be comparatively cheap.

Experience the world over teaches us that the old highways must be widened when the opportunity arises but a community without a definite plan or program lets these opportunities for widening pass by.

PENNSYLVANIA STATE COLLEGE OFFERS CORRESPONDENCE COURSES

In order to provide men the state needs for highway work, the Pennsylvania State College engineering extension department, which now reaches more than 7,000 workmen over the state in industrial training work, has prepared and is now offering a course in highways. It is especially adapted to the man now engaged on highway construction or maintenance so that he can take it while he is on his job, especially during the winter months when work is at low tide. It is so arranged that an ambitious student can cover the work after activities close in the fall and before they open in the spring.

N. C. Miller, head of the engineering extension department at the college, announces that this course is probably the first one of its kind that has been made available to all people interested in one of the most important problems of the present time. Great interest has been manifested in the course though it has been available for only a few weeks. To the young man who intends to enter college at a later date, it has the added attraction that the College gives credit for this course toward a college degree in engineering.

For those interested in the study of highway problems, Mr. Miller says that the course can be taken either by correspondence, when the men are by themselves at home, or at an isolated construction camp, or classes can be arranged where there are a number of men studying in the same community. Questions will be asked in the course and problems worked out on paper by the students and corrected by the faculty of the college.

A number of road building contractors in the eastern part of the state have interested their employees in the college proposition, and assistance in advising the men of the opportunity has been given by the State Highway Department.

The course calls attention to the administration, legislation and organization of highway work in state, county and city. Training in surveying and mapping is given to meet the requirements of the usual run of work. Emphasis is put on the importance of grading and drainage as related to the different kinds of country encountered. As about 90 per cent of the highways of this country are made of clay, sand and gravel, these roads are particularly studied in this course, which should lead to more economical construction and maintenance as well as better roads of these materials. Dust prevention receives its share of attention and all manner of road building materials, their advantages and disadvantages are considered thoroughly. Highway structures, street cleaning, snow removal, sidewalks, curbing and gutters are also considered, as well as tests of highway materials.

MUCH HIGHWAY CONSTRUCTION WAS COMPLETED IN DECEMBER

December with its snows and wintry weather is not the best month of the year for building roads, yet during last December there were completed 1,155 mi. of federal highways under the supervision of the Bureau of Public Roads, United States Department of Agriculture. The mileage is represented in roadways that were nearing completion as winter started and were finished during the month.

In addition, according to a compilation just completed by the department, considerable progress was made toward the completion of 15,834 mi. more of highways still under construction. At the end of November these roadways were 68 per cent complete; at the end of December they were 70 per cent finished. Work on the uncompleted projects is going on as fast as weather conditions and other factors permit. On some of the roads, which lie in the southern states, considerable progress is being made. Others, situated in more rigorous climates, show less advancement.

Up to the first of the year there had been completed, under the supervision of the department, 12,907 mi. of Federal-aid highways during the five years that the work has been in progress. The total estimated cost of the 12,907 mi. of completed highways was $221,739,710, of which $95,054,184 was federal-aid funds, the remainder of the expense being borne by the states. The estimated cost of the 15,834 mi. of federal-aid roads under consfruction January 1 is $275,652,104, of which the Federal Government will pay $117,049,690.

MEETINGS

Calendar of Coming Meetings

Feb. 12-17—Conference on Highway Engineering.—Eighth Annual Conference, University of Michigan, Ann Arbor, Mich.

Feb. 21-22—Kentucky Association of Highway Contractors—Annual meeting, Louisville, Ky. Secretary, D. R. Lyman, Louisville, Ky.

June 4-6—American Association of Engineers—Annual convention, Salt Lake City, Utah. Secretary, C. E. Drayer, 63 E. Adams St., Chicago, Ill.

June 26-July 1—American Society for Testing Materials—Twenty-fifth annual meeting, Atlantic City, N. J. Secretary, C. L. Warwick, Engineers' Club Bldg., Philadephia, Pa.

NATIONAL HIGHWAY TRAFFIC ASSOCIATION

A public meeting of the National Highway Traffic Association will be held on Feb. 14 at 8 p. m. at the Automobile Club of America, N. Y. City. The subjects for discussion are as follows: Adequate Parking Facilities for Passenger and Commercial Motor Vehicles; Segregation of Slow Moving Traffic; Relief Measures for Terminal and Ferry Congestion.

NATIONAL SLAG ASSOCIATION

The annual meeting of the National Slag Association was held on Jan. 28 and the following officers elected: president, L. A. Beeghly, Standard Slag Co., Cleveland, O.; vice-president, C. E. Ireland, Birmingham Slag Co., Birmingham, Ala.; secretary-treasurer, H. J. Love.

PORTLAND CEMENT OUTPUT IN DECEMBER

The production of finished portland cement in the United States in December, 1921, was approximately 6,559,000 barrels. As compared with the production in November, 8,921,000 barrels, this represents a decrease of 2,362,000 barrels. A seasonal decline was to be expected, and though the production in December, 1921, was less than in December, 1920, it was about 14 per cent. more than the average for December from 1917 to 1921. The production in 1921, 98,293,000 barrels, was over 98 per cent. of that in 1920, and was greater than that for any other year except 1920.

The shipments in December, following the usual trend, showed a decrease from those in November. The movement in December, 3,697,000 barrels, was over 9 per cent. greater than that in December, 1920, but was slightly below the average for December during the last five years. The shipments made during the last half of 1921, 54,976,000 barrels, were approximately the same as those made during the last half of 1920. The total shipments in 1921, about 95,051,000 barrels, were nearly 99 per cent. of those in 1920.

Stocks of about 11,938,000 barrels of finished cement were in the hands of the manufacturers at the end of 1921, as compared with 8,941,046 barrels at the end of 1920. This total exceeded the average stocks in hand at the end of the year from 1917 to 1921 by over 27 per cent. From April until October stocks of finished cement decreased steadily, but in November and December they increased. Stocks are usually accumulated during the colder months in anticipation of the large requirement in the months of active demand.

PERSONAL MENTION

W. E. Sarver has been appointed City Engineer of Canton, O.

Joseph M. Tracy has resigned as city engineer of Ogden, Utah.

C. J. Tilton has resigned as Town Engineer of Phillipsburg, N. J.

W. S. Craven has been appointed City Engineer of Ogden, Utah.

O. P. Thomas has been elected Borough Engineer of Conemaugh, Pa.

H. W. Mixell has been appointed Town Engineer of Phillipsburg, N. J.

John A. Guiley has been appointed Construction Engineer of Canton, O.

Arthur B. Roberts has been appointed Director of Public Works, Cleveland, O.

C. R. Goodrich has been appointed Commissioner of Public Works of Utica, N. Y.

A. E. Doucet has resigned as Director of Public Works of Montreal, Que., Canada.

Oscar A. Piper has been appointed Superintendent of Streets and Sewers of Seattle, Wash.

Frank L. Gibbony, formerly City Engineer of Roanoke, Va., died recently at Charlotte, Va.

James Costello has been appointed Division Road Engineer in Allegheny County, Pennsylvania.

Luther G. Zerbe has resigned as Superintendent of Streets of Canton, O., to enter private practice.

G. P. Graham, formerly Deputy City Engineer of Albany, N. J., has been appointed District Engineer by the Asphalt Association, with headquarters at Albany.

H. R. Helland, has resigned as City Engineer of Waxahachie, Tex., to enter into partnership with his father, who was formerly City Engineer of San Antonio.

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

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TABLE OF CONTENTS

*Resume of Cooperative Road Improvement and Future Policies. By Thomas H. MacDonald . . 95

Systematic Survey of Gravel for Road Purposes. By Wallace F. Purrington 100

University of Illinois Short Course in Highway Engineering 103

Uniform Legislation as Affecting Highway Traffic and Highway Transport. By D. C. Fenner . . . 104

The Road in Verse 105

Large Road Mileage Built Last Year 105

Road Information Hard to Obtain 105

EDITORIALS:

Limitation of Federal Aid Funds 101

Gravel for Road Construction 101

Road Work in National Forests 101

Highway Traffic Problems 101

MEETINGS:

Calendar 106

Further Federal Aid Urged by Washington Conference 106

PERSONAL MENTION 106

OBITUARY 106

*Illustrated article

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THE HIGHWAY CONTRACTOR AND ROAD BUILDER

Vol. LXII. NEW YORK, N. Y., FEBRUARY 15, 1922 Number 7

Resume of Cooperative Road Improvement and Future Policies*

By THOMAS H. MacDONALD†

We comprehend now as we have not understood in the past, the influence exerted upon our national life by transportation. It is the factor we find now interposed between supply and demand, between the starving thousands and food supplies, between producer and consumer. It is the factor whose absence separates, and whose presence ties together communities, States, and the nation as a whole. To supply adequate and increased transportation facilities is the motive which has influenced the American people to increase the number of motor vehicles in use since 1910 more than 1800 per cent. To provide the complement of the motor vehicle, the improved highway, is the underlying reason why the larger funds have been made available from State and Federal sources. The proper combination of these two serve a definite purpose in the nation's economy—this is highway transportation in the making.

More enlightening than any statistical quotation is the graphic picture of motor vehicle registration and highway funds. The widespread opposition to state programs of highway building during the years from 1910 to 1916 when motor vehicles were pyramiding at an unforeseen rate, the increased funds made available following the Federal Aid Act of 1916, the stagnation of actual expenditures during 1917 and 1918, the competition of industry of 1919 for materials, labor, and even more important, for rail transportation,—all these have played a major part in producing the wide difference between the improved highways demanded by 9,300,000 motor vehicles and the actual new mileage constructed.

The record for 1920 and 1921 is better, but let each State highway department make plain to the people of its State that for less than three years of the past five since large funds became available, have conditions permitted highway construction of an increasing scale. The facts which are true of construction are true also of maintenance.

The chartered figures of expenditures are not exact, yet such error as exists lies principally in those funds which are raised and used locally and which do not reach the principal highways or result in more than haphazard repairs of local roads. For the past several years, since every State has had a highway department, the figures are substantially correct as to all funds which are a factor in this discussion.

The conclusions are self-evident.

1. During the period 1910-1921, the potential number of motor vehicles demanding highway service increased more than 1800 per cent.; our actual expenditures for construction and maintenance increased about 400 per cent.

2. During the period 1910-1918, motor vehicles increased more than 1100 per cent., highway expenditures about 140 per cent.

3. During the period 1918-1921, motor vehicles increased about 700 per cent., and highway expenditures about 260 per cent. of the 1910 figures.

But even these figures do not truly represent the differential between the demands for highway service and our actual production. Without attempting impossible refinements, if the cost index of 1918 be taken at two and that of 1910 at one, the actual increase in production of 1918 over 1910 was only 20 per cent., and if the index for 1921 is taken at 1½, the actual increase in production of 1921 is only about 233 per cent. over the 1910 figure. That is, taken as a national aggregate, the number of motor vehicles, all at least potential users of the highways in some degree, has increased in eleven years since 1910 more than eighteen times. Our greatest annual production of serviceable highways measured by the construction and maintenance expenditures has been

*Paper presented at the annual meeting of the American Association of State Highway Officials.

†Chief, Bureau of Public Roads, U. S. Department of Agriculture.

not more than two and one-third times the production of 1910, and it has been only within the past three years only that production has gone forward at a rate approximating the maximum.

It seems to me a duty as well as a very great privilege to bring before you this viewpoint, clearly defined against the background of fact, of our progress in the development of highway transportation and of the relationship of the highway organizations, State and Federal, to this development.

Those who are a part of these organizations have the good fortune to be engaged in their chosen field when the greatest development that can ever come is taking place. The first two or three years of something more than a decade of major road building have passed. What has gone before has been largely preparatory—a period of organization. What will come after,—perhaps ten, perhaps fifteen years later,—must by then be largely standardized, largely routine. The highway organizations that come after will not have such opportunities to render good, or, equally true, bad service, or be able to progress so far in a limited time in advancing highway engineering and administration, and in combining the motor vehicle and improved highways into scientific highway transportation.

This body of individuals and their associates will determine the efficiency of the highway systems of the future. Are you accepting the responsibility? Do you say to yourself, seriously and thoughtfully, "Upon my efforts in a large degree depend the future service the highways will render? If I yield to political pressure, to selfish interests, to some stubborn opposition, and fail to plan and to build the highways the people of my State ought to have, not only the present but succeeding generations must suffer."

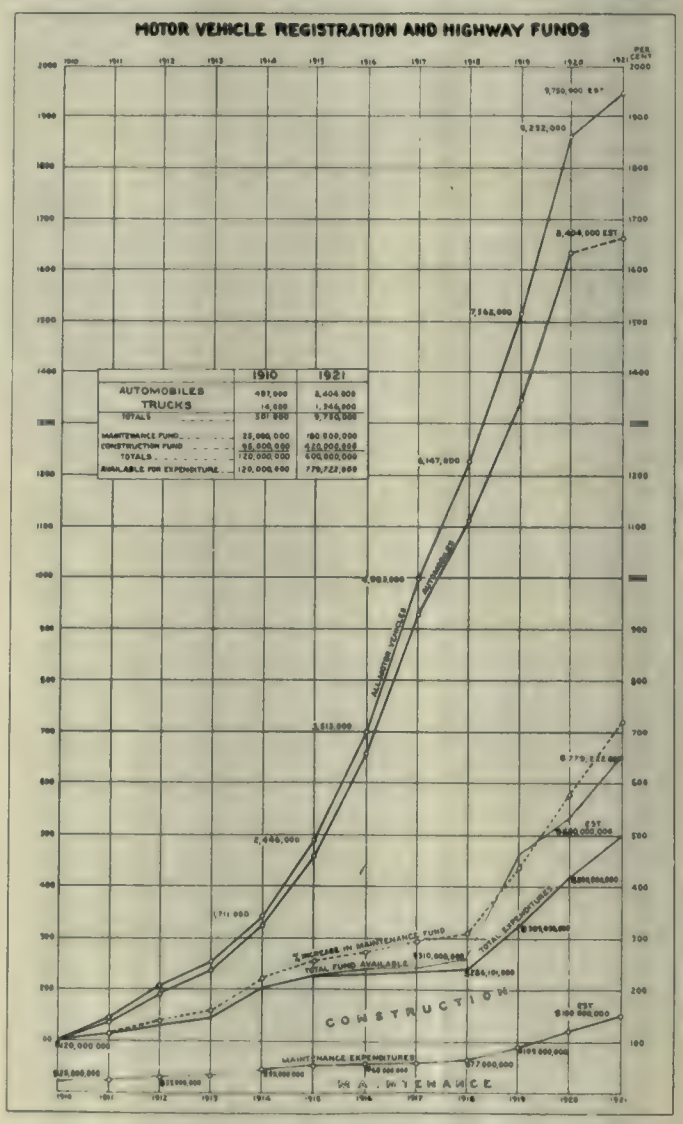
This organization must awaken to a responsibility of placing before the public at large the real facts concerning highways and their relationship to highway transportation service. It must speak with authority and emphasis. It must take upon itself the serious responsibility of leadership in directing public thought and education, not by the arrogant methods of the demagogue, but by the intelligent dissemination of facts and principles founded upon knowledge and experience. Nothing as big as the highway improvement program now actually under way is safe from attack through selfish, short-sighted or ignorant motives. Nothing will carry on the spirit and interest of the public through the long period ahead except an appreciation and a belief in the integrity and usefulness of the results accomplished.

I do not wish to fail in showing my belief and enthusiasm in the possibilities and opportunities that lie ahead of the highway organizations. But I wish less to fail to place upon the conscience of each individual, regardless of the rank he holds, his responsibility. I want to see this organization accept the fact that the success of the future highway program is dependent upon the character and ideals maintained by the component forces, and that the failure of any one of these, Federal or State reacts adversely upon the whole.

It is not possible to define for a definite period of time the exact progress made for the United States as a whole, for there is no fixed point common to all the States. Yet, from the standpoint of highway service, I list our outstanding progress for the past two years in this order.

1. The increased highway service made possible through the establishment of proper methods and the expenditure of more adequate funds for maintenance.
2. The increased highway service resulting from new construction.
3. The adoption and enforcement of better engineering standards.
4. The improvement in the administration of highways as a public utility.

Although the new construction has been very large,



the mileage of highways of all types that have been brought to a serviceable condition or restored after a period of inadequate repair, is still greater. The outstanding results secured from the distribution of the large quantities of war surplus materials and equipment

are found in the better and more extensive highway maintenance made possible. The Bureau estimates that by the end of the year war surplus to the amount of approximately $150,000,000 in value will have been distributed for use in highway improvement.

It is my purpose to submit detailed schedules of the cooperative construction work, to be included in the published reports. Without the detail by States, as a national program the following showed the program by years in placing new work under way.

TABLE I.—FEDERAL AID PROJECTS UNDER CONSTRUCTION AND COMPLETED BY CALENDAR YEARS.

Calendar Years	Estimated Cost For Year	Estimated Cost Accumulated	Federal Aid For Year	Federal Aid Accumulated	Miles For Yr.	Miles Accum.
Previous to and including 1918	$ 18,088,000	$ 18,088,000	$ 7,568,250	$ 7,568,250	1706	1706
Previous to and including 1919	119,746,270	137,834,270	52,210,105	59,778,355	8071	9777
Previous to and including 1920	212,292,815	350,127,085	89,904,752	149,683,107	11754	21531
To December 1, 1921	141,362,865	141,362,863	491,489,950	209,583,722	6986	28517

On November 1, 1921, our records showed the following mileage and costs of roads completed and under agreement:

TABLE II.—MILEAGE AND TYPES COMPLETED AND UNDER AGREEMENT NOVEMBER 1, 1921

Type	Cost—Total	Cost—Federal Aid	Mil'ge
Graded and drained	$55,704,253	$24,721,021	6,864
Sand clay	22,226,362	10,495,172	2,696
Gravel	104,614,067	47,192,895	10,044
W. B. macadam	22,452,779	9,729,201	1,291
Bituminous macadam	41,412,557	18,646,066	1,323
Bituminous concrete	23,445,375	9,299,864	772
Concrete	184,021,245	75,600,279	4,654
Brick	22,039,845	6,925,483	444
Bridges	20,235,200	8,525,395	*47
Totals	$496,151,683	$211,135,376	28,135

*Includes approaches.

The distribution of costs and types on a percentage basis for the projects summarized are as follows:

TABLE III.—DISTRIBUTION OF COSTS AND TYPES ON PERCENTAGE BASIS ON PROJECTS COMPLETED AND UNDER AGREEMENT, AS OF NOV. 1, 1921.

Types	Percentage of estimated total cost	Percentage of federal aid	Percentage of total mileage
Graded and drained	11.2	11.7	24.4
Sand-clay	4.5	5.0	9.6
Gravel	21.2	22.4	35.7
Water-bound macadam	4.5	4.6	4.6
Bituminous macadam	8.3	8.8	4.7
Bituminous concrete	4.7	4.4	2.7
Portland cement concrete	37.1	35.8	16.5
Brick	4.4	3.3	1.6
Bridges	4.1	4.0	0.2

As of November 25 the records of the Bureau show that of the total allotments to the States under the two first appropriations, $266,720,000 there has been placed under agreement with the States Federal Aid funds in the sum of $213,048,000 for 28,419 miles of highways. Of this mileage there has been completed the equivalent of 21,000 miles. You will note, therefore, that there now remains the balance of 53,702,000 to be placed under agreement from the old appropriation. From the Federal Highway Act appropriation of November 9, there has been apportioned to the States $24,375,000, available now, and $48,750,000 available January 1, 1922.

As a foundation for the consideration of future policies under the new legislation, the Secretary of Agriculture has authorized and requested me to express clearly and without reservation his position that in the formulation of the new rules and regulations required, and in the administration of the law, the Department will request the counsel of this Association through its proper committee. The Secretary is greatly impressed with the possibilities and responsibilities of the new Act, and the truly cooperative spirit which must underlie the functioning of both the State and Federal organizations to make the greatest and surest progress.

The Act itself is remarkably comprehensive in defining and demanding a systematic plan, national in its extent, for future highway development. None of us have had, or are ever likely to have a more seirous responsibility than the one imposed of selecting the Federal Aid system to be composed of the most important highways, articulating not only within the States, but with the systems of the contiguous States. Here is an opportunity to do a big, basic work, such as comes to few in the course of a lifetime. The individual who fails to vision the importance of the task has no moral right to hold a position of authority in its performance. From a conception of highways as a purely local institution, a viewpoint we held for over a half century of our national life, we progressed to an acceptance of their importance to the State. This attitude persisted for another quarter of a century, until, thru the universal use of the motor vehicle, the transportation crisis of a great war, the repeated threats of extensive railroad tie-ups, and the results already secured with Federal Aid, we have, in the short period of five years, visioned our more important highways extended and inter-connected to form a vast network, serving local, State and national traffic, only limited by the confines of the United States. This is the conception which has been written into the law, and which, because of the projected effect of that which is done now into the future, lifts the importance of this requirement, that is, the selection of the Federal-Aid system, above any other principle or duty therein announced.

This work must not be hurriedly done, but because of the unemployment situation urgently demanding every possible relief that may be obtained through the highway program, projects will be approved without delay for the building of roads which the States and the district engineers of the Bureau agree will lie upon the Federal Aid system. All funds available which have not advanced to at leaast the approved project statement stage come under the requirements of the new Act. Each district engineer is fully informed as to the procedure for "interim" projects, which is so simplified that if important projects are chosen in good faith there will be no delay in securing favorable action.

The Department will do everything possible to expedite projects that can bring any relief from the unemployment crisis now, or that will shorten the winter season of inactivity in road building in the northern States. The revised regulations will not be issued until they have been considered in detail with the representatives of the Association.

There can be no doubt as to the clear intent of the law to provide for a system of roads which shall include those which are now and which after improvement are to become the major traffic lines. The different states of improvement to which the States have progressed, and all the variations between them of topography, of population distribution, of industries, of development of natural resources, must necessarily be reflected in the laying out of the system. These details must be worked out between the States themselves and the Bureau of Public Roads. Because of these wide variations, it is only possible to suggest some of the major considerations. We do not minimize the importance of the local traffic. To care for this class properly will, in general, always be the first objective of highway improvement. Our conception is rather that a choice of highways shall be made which, regardless of the order of improvement, will eventually join into a well-conceived network crossing both county and State boundaries. Thus, while the immediate needs of a State or a district may determine priority of construction, each new link brings nearer the completion of the system as a whole.

In the western States the major lines will be largely fixed by topography, but by the same token, because long routes will be determined by single strategic points such as a mountain pass, it is the earnest hope of the Bureau that the States affected will reach an agreement based on the future service that is to be rendered, not only to the local, but also to the inter-State and national traffic.

In the same spirit that the United States by a courageous and generous policy has made possible definite progress in the limitation of armaments, to be followed by a consequent decrease of national expenditures for potential destruction, it is my sincere belief that the highway organizations will make possible through mutual agreement the consummation of a splendid national system of highways. This comparison is not lightly made, for the program ahead involves hundreds of millions of dollars, but with this essential difference, that this huge expenditure will be for a constructive, nation-building purpose. In the great agricultural districts where the major road development is still ahead, and where the connecting up of continuous routes will at the same time serve the local traffic equally with other projects, it is hoped that the States will recognize that duty imposed upon the Department, expressed in the language of the law, "The Secretary of Agriculture shall give preference to such projects as will expedite the completion of an adequate and connected system of highways, inter-State the character."

the eastern States, some of them with a large mileage of improved roads, it might appear that the selection of a system is not so important, yet it seems to me that it is here that our greatest traffic problems lie. It will be a comparatively short time, because of new construction and better maintenance, until the trans-continental tourist will be provided with roads that are entirely serviceable throughout the seasons of the year when other conditions favor such travel. The really serious traffic problems lie around and between large centers of population. It must be remembered that for roads built previously many engineering details such as alignments, widths, types, were planned prior to the advent of the motor traffic, and for the slower, lighter, horse-drawn vehicle use. The consideration of weight, speed, safety, numbers, which now must govern design, had not yet become the controlling factors. The traffic lines are from town to town, and in general follow through the most congested parts of population centers. As some of the principles which we must properly work out, the following are suggested:

1. The development of parallel lines to divide heavy traffic through thickly populated districts.
2. The development of direct, short mileage routes, although on these routes there may now be a less amount of improved roads than on routes now followed.
3. The building of inner or outer belt lines around congested centers.
4. The reconstruction of weak sections for heavy truck traffic.
5. The widening of main routes near the largest cities or between cities where the distance is short enough to carry uniform traffic.
6. Proper connections with the routes of adjoining States.

Possibly there are many questions as to the future surfacing policies. The changes in types and specifications which will be sought from time to time by the Bureau will be based upon the more accurate knowledge which is being obtained rapidly through research and through the detailed studies of the behavior of modern designs under traffic. The requirement of the 18-foot surfacing is constructed to mean that this is fixed as the minimum two-way road, where the construction is to be considered complete as first put down. This requirement will not preclude the building of a narrower pavement in those districts where the traffic does not yet justify the two-way width. I am yet to be convinced that we may not properly build now in many sparsely populated districts one-half of the final width of pavement in order to complete mileage between points, if all the other work is done to provide for the full width construction later.

To insure maintenance, the strongest possible requirements have been written into the law. The Department may not slight its responsibility, and the attitude of the whole national administration demands the utmost fidelity in the continuous upkeep of the highways built. The position taken by the President in his published addresses is well known. His statements to the Executive Commit-

tee of this Association, who counseled with him while the present legislation was under consideration, the statements of the Secretary of Agriculture in presenting the completed legislation to the President for his signature, all leave no possible doubt as to the position which must be taken by the Bureau in enforcing the provisions as to maintenance.

We are not left in doubt as to the meaning of the word "maintenance." The law itself states, "the term maintenance means the constant making of needed repairs to preserve a smooth-surfaced highway." Further, "such State shall make provision for State funds required each year * * * for construction, reconstruction and maintenance of all Federal-Aid highways * * * which funds shall be under direct control of the State Highway Department."

The Bureau earnestly hopes that it will not be required to take over a single mile of highway for maintenance, but the responsibility is imposed, and this provision of the law will be enforced to the letter. It is a well-established principle that proper maintenance will result only if some form of patrol is organized that places direct and continuous responsibility upon someone for the condition of each mile of road, and the Bureau will not consider that the States are properly living up to the requirements of this Act until such a system is established. I do not use "patrol" in the technical sense to distinguish it from the so-called "gang" system, but rather, the proper combination of patrol and gang systems to meet the particular conditions of each State. If there is one word to be accented more than any other, it is the term "constant," and to this should be added "automatic."

Personally, I am more than delighted that the sliding scale has been established to gauge the cooperation required in the public land states. I do not regard the establishment of this scale as a concession to the west. It seems to me to be only a proper and just recognition of the responsibility which the United States as a whole must shoulder—that of improving those highways necessary through the public lands whose future utility is problematic.

It is not necessary to touch upon all the points of the law. I have endeavored to accent the establishment of the system of Federal Aid roads as beyond all other principles, the most important written into this law. Of only slightly less importance is the requirement as to maintenance. While our thoughts may run to large construction programs, and the details of types and materials to be used, let it be remembered that we are providing highway service, and that the degree of service rendered is determined by the lay-out of the system, and by the condition in which every mile of road within that system is maintained constantly. Every State which has established a State system of highways has found those highways almost immediately abandoned by the counties or other local subdivisions. I trust that each State in which highways are taken into the Federal Aid system, which have not up to this time been established as State highways, but have been under the jurisdiction of the local boards, will recognize this principle and make immediate plans under which all parts of the system will come under the jurisdiction and maintenance of the State without waiting for their construction.

The Bureau of Public Roads will proceed under the provisions of this Act on the assumption that each State will recognize the mutual responsibilities imposed upon the State and upon the Federal organizations, and will bring its operations at once into harmony with all the provisions. Also, that each State will in fairness recognize the greater responsibilities, restrictions and requirements imposed upon the Federal Bureau. The Bureau does not seek initiative. It does not seek to direct the States but to cooperate with them. There is now a plan of action for the guidance of both organizations that is so clear and so explicit that neither can escape the responsibilities imposed. The Federal requirements are fairly defined and will be sincerely and faithfully enforced. Among all of the 48 States, I know of no cases where it is not possible to cooperate fully—certainly no physical or financial difficulties are insurmountable,—and if difficulties develop in the administration of this law, they will come from a wrong attitude of mind on the part of one or both of the organizations. We can and will eliminate any possibility of such only through a mutual consideration and respect each for the viewpoints and obligations of the other.

Referring once more briefly to the diagram, it is evident that a great misconception exists in the public mind as to the service which is being rendered by the highways. During the very long period that construction and maintenance were lagging far behind the increase in traffic, it is not to be wondered at that our highways showed a material depreciation. Through the war period, with the greatly increased use of heavy traffic units, particularly at just the seasons of the year when the road surfaces are carried on weakened subgrades, some roads did break up seriously. But this depreciation in general has not continued, and more than this, the effect of the lag in maintenance has been practically obliterated by the increased maintenance during the past three years, and by the reconstruction of the weaker sections, until our roads are in a far better condition today than they have ever been in our history. This fact in itself controverts successfully any general accusations against our modern highways, of failure to carry the loads imposed. Think of the conditions in your own State. Are not the roads far better than they have ever been? And yet perhaps many of you feel that in some other States the roads have been and are depreciating rapidly. I have been unable to find such evidence. Roads that during the war, because of unusually heavy traffic and lack of maintenance, were seriously depreciated, have since been brought back into a state of better repair than they have ever been. Cheaply constructed roads, roads that were built before any consideration of present-day traffic, are

being held up through adequate maintenance on some of the heaviest traffic lines in the country.

The whole purpose of highway building is to make possible highway transportation, and the cost of the transportation must be reduced as low as possible. Therefore, restrictive legislation which limits too greatly the loads to be hauled on the highways should not be tolerated, as it is against a proper public policy. Legislation regulatory of the traffic on the highways should take into account that there are many factors which govern the traffic depreciation of our highways. Laws which blindly fix some weight to be moved on the highways may prohibit the really profitable traffic and allow less economical and more destructive vehicles to operate practically unchecked. Both weight and speed are major factors in their destructive effects upon the highways, but the distribution of the load, the relation of the sprung and unsprung weights, the tire equipment,—all have an important effect. From the research of the past two or three years, and from the practical experience of the highway organization, we are accumulating sufficient knowledge to engage understandingly on a determination of the character of legislation which will result in a sound public policy. The solution of highway transportation lies in the proper adjustment, no less of the motor vehicle to the road than of the road to the motor vehicle. I hope to see no conflict develop between the States in the determination of traffic regulations. Such would destroy in a large measure the utility of a Federal Aid system of primary highways. Rather, because the system will for a long time be non-uniform in its carrying capacity, much discretion should be allowed the State highway departments in determining the loads which are to operate upon specific sections of highways, and further, much discretion should be allowed the departments in the making of seasonal restrictions where climatic conditions are such that there are periods when the roads normally fully capable for carrying heavy loads, are for a short time carried on uncertain subgrades. Here is an opportunity for the highway builder and the motor truck manufacturer to cooperate to serve the public's interest.

One other point is causing the public much concern. It is often stated that highways have gone to pieces and must be rebuilt. Engineers have been prompt to develop methods of improvement which are salvaging practically the full value that was originally invested in the highways. For example, some of the older macadam roads in New York State, lightly built, which are now heavy traffic lines, have been widened by concrete roadways on either side preserving a strip of macadam, say 6 feet wide in the center, thus giving a 24-foot usable surface by the addition of 18 feet of new construction. The remainder of the macadam width is sacrificed and the material spread to form a better base under the new construction. This is only one example of so many successful operations of like construction that it may be taken as a principle that if roads are well maintained when traffic becomes so heavy that reconstruction is necessary, the major part of the investment can be preserved and be built into the new highway as an integral part. It is my judgment that our heaviest traffic lines of the future will be developed in this manner, for we must recognize the principle that at the present time the big task is to get a mileage of surfaces that can be maintained under the traffic. Perhaps the principle that we should remember is to do the fundamental work right. Road surfaces are built for use and we must expect them to wear out. The one thing that we must do is to furnish highway service, for this is an essential factor of highway transportation, and we must rely on highway transportation to pay the major portion of the costs of the whole construction and maintenance program ahead.

Systematic Survey of Gravel for Road Purposes*

By WALLACE F. PURRINGTON†

Five years ago, when work was started in New Hampshire on the testing of gravels, it was immediately seen that samples taken at random would furnish but very little information. Limits for the wearing qualities for instance, could not be determined until a very comprehensive study of the whole state was made. The question arose, if any given gravel showed poor results, did this condition indicate the quality of gravel in other banks near by?

Nature has a habit of doing everything according to some law. There was at the outset, then, reason to believe that the quality of gravel at any one place was determined by some one of these laws.

For the purposes of this paper, we will consider gravel to be waterworn pebbles mingled with sand or clay. Throughout New England and rather generally in the northern states, the deposits of gravel came from the melting of the great continental ice sheet at the close of the ice age. Since that time some of these gravels have been redistributed by rivers or by waves and they may even still be undergoing rearrangement and alteration by these agencies.

The bed-rock of New Hampshire is composed of crystalline rocks commonly classified as igneous and metamorphic. We are neither blessed nor cursed with rocks of sedimentary origin. The results of the movement of the Ice Sheet can be seen today by the glacial scratches or "striae" still found upon the surface of exposed hard ledges. One of the first steps taken at the beginning of our survey was to make a map show-

(Continued on page 102)

*Paper presented at Nineteenth Annual Convention of the American Road Builders' Association.

†Chemist and Testing Engineer, New Hampshire Highway Department.

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

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Copy for classified and other advertisements where proofs are not required will be accepted until noon on Monday of the week of issue.

Articles by road builders are solicited. They should be short and, if possible, accompanied by photographs. Those accepted will be paid for at current rates.

Volume LXII. February 15, 1922 Number 7

LIMITATION OF FEDERAL AID FUNDS

While no one can question the necessity of the Federal Government to curtail its expenditures, the proposal of President Harding to limit federal aid appropriations to $75,000,000 a year would appear to be misapplied economy. The United States, although it has now many thousands of miles of improved highways, is in urgent need of better highway transportation facilities in all sections of the country. The commercial activites of this country are developing rapidly and greater demands as a consequence are being imposed upon transportation. The railroads are not keeping pace with this commercial growth—no new trackage is being built, in fact, short branch lines are being abandoned and it might truthfully be said that railroad trackage is actually shrinking, in spite of the fact that the movement of commodities is greater than ever before. Under this new order of things, our highways are increasingly important.

Instead of diminishing the amount of funds to be made available each year, Congress ought to increase road appropriations, for the states are now prepared to go forward with road work on a grander scale than ever before. Efficient highway organizations have been built up and the drawbacks which prevailed after the close of the war, such as shortage of labor, materials and railroad facilities, do not exist now. The pruning knife could much better be applied to some other activity of the Government than to federal aid highway construction.

GRAVEL FOR ROAD CONSTRUCTION

Because gravel makes a good road at small cost and is found in all parts of the country, it is natural that it should be the most universally used road material. Yet because gravel is so readily available, it sometimes happens that insufficient thought is given to the selection and use of this material in road work. As Wallace F. Purrington, Chemist and Testing Engineer of the New Hampshire State Highway Department, remarks in an article printed elsewhere in this issue, "Someone has remarked that if given an Italian and a shovel he would find more gravel than a geologist could. Reason and experience indicate, however, that both the shovel and the geological understanding are essential to any thorough and economical search for gravel."

ROAD WORK IN NATIONAL FORESTS

An important phase of road building in this country is the work being carried on by the U. S. Forest Service in the National Forests, as described last week by F. E. Bonner, Acting Chief Engineer. Since 1905 about $20,000,000 has been spent on the construction of forest roads and last year $15,000,000 was appropriated by Congress to carry on the work. This recent appropriation will speed up the opening of timber reserves and will make accessible to automobilists much territory rich in scenic beauty.

It is estimated that approximately 40,000 mi. of roads are yet to be constructed to provide adequate highway systems in the 156,000,000 acres of national forests in this country. This construction will involve a total expenditure of approximately $140,000,000. For the time being the Forest Service has sufficient funds to carry on its work of road development, but it has only enough to make a beginning and should in the future receive appropriations to enable it to carry out its plans without interruption.

HIGHWAY TRAFFIC PROBLEMS

In an article appearing elsewhere in this issue Thomas H. MacDonald, Chief of the U. S. Bureau of Public Roads, points out some of the salient highway traffic problems now confronting road builders in this country. To Mr. MacDonald's mind the location of roads bear a very important relation to future traffic problems and greater consideration must be given to the following: "the development of parallel lines to divide heavy traffic through thickly populated districts; the development of direct, short mileage routes, although on these routes there may be a less amount of improved roads than on the routes now followed; the building of inner or outer belt lines around congested centers; the reconstruction of weak sections for heavy traffic; the widening of main routes near the largest cities or between cities where the distance is short enough to carry uniform traffic; proper connections with the routes of adjoining states."

A SYSTEMATIC SURVEY OF GRAVEL FOR ROAD PURPOSES

(Continued from page 100)

ing by colors the various areas occupied by different types of rock. The diection of glaciation had been worked out by the State Geological Survey under Hitchcock years before. Our success in future lines of investigation was to a great extent dependent upon this very detailed knowledge of the bed-rock and glaciation which was available at the start.

The ice sheet as it slowly spread southward across New England, ripped, ploughed and ground up everything in its path. Eventually the climate changed, the ice edge began to melt back, resulting in torrents of water which moved the frozen rock material or drift, building up certain surface formations which are designated as eskers, kames, washplains and deltas. The subsequent action of rivers has cut terraces, and upward movements of the earth's crust have raised old sea beaches to heights far above their original level. These formations, from the road builder's standpoint, are very valuable for these are the sources of his gravel.

There are three well defined rock areas in the state; on the extreme west, running north and south and bordering on the Connecticut River, is found a strip of slates or slaty schists; directly east of this area a loose-textured granite is found and still further east, in the center of the state, lies a great area of crystalline schist. Referring to our bed-rock map, we find that the scratches cut by moving ice sheet show a general northwest southeast direction. Our river systems, likewise, flow in a general southerly direction. Let us consider then what our problem becomes. The ice sheet moving into the state on its journey southeastward picks up great quantities of the slate of that district. As it strikes the granite belt it gathers more and more granite which dilutes the slates. As the distance increases the slate content becomes almost negligible. In this case, the slate is an extremely soft material and the granite is but little harder. The result then, is a varying mixture of two very soft rocks and as a consequence, we should rightly expect to find a gravel with but poor wearing qualities. Let us trace the course of the glacier still farther east into the crystalline schist area. Here we have a rock which at one time was sedimentary but which was subsequently hardened by heat and by becoming soaked with underlying granite masses. The gravel from this area proves to be highly resistant to wear. It is obvious that the ice sheet leaving the soft slate and granite begins to pick up the harder schist and as a consequence we find that the further southeastward we go, the stronger the gravel becomes.

The melting of the ice sheet concentrated and sorted the rock fragments. The condition resulting was dependent upon the amount of flow of water at any one point. Where a glacial river containing an overburden of material flowed through a narrow canyon or tunnel in the ice sheet, we find an esker or steep sided ridge. Where the material collected under more irregular conditions at the side or front of the glacier, we find kames. When the outflowing rivers discharged into lakes or the sea deltas and washplains were spread. The more force that the water had, the larger were the materials which were transported. We find then that our coarser materials are in the eskers and kames and the more sandy gravels are in the deltas and washplains.

In a study of gravels, there are certain geological facts that must be known; the nature of the bed-rock at any point, the nature of the adjacent bed-rock on the side from which the great glacier came and the topographic features.

Some of the most valuable information found by the survey of New Hampshire gravels was obtained by making counts of the stone composing each gravel, i. e., the percentage of granite, slate, schist or other rock type. For this purpose at least 100 pebbles, taken at random, were counted and the results noted. By such a quick and simple measurement of composition it is quite possible to draw conclusions as to the strength of the gravel and so of its value for road purposes. Ordinarily there is not, in any given town, a great difference in the quality of gravel to be found. There are indeed, differences in the proportion of sand, pebbles and cobbles. This is true of the material found even at different points in the same bank. If, when gravel deposits were formed, the force of water with its load of material had been uniform, we might have had homogeneous deposits. Such was not the case where eskers and kames and other glacial gravel deposits were built, consequently, one hardly knows what is to be found in any part of a deposit that is not visible. To the writer's mind any sample submitted to a laboratory for grading from gravel deposits like these is a mere waste of time. There may be some merit in testing a river of washplain gravel in this matter for these are more uniform. Other investigators have reached the same conclusions regarding the absurdity of laboratory grading of samples from glacial gravels. An intelligent manipulation of any pit will give better and more reliable results than any arbitrary grading system that may be devised.

Knowing from field studies, the nature of the deposit, the composition of the gravel as revealed by the stone count, the amount of gravel available and its probable grading, the testing laboratory has to pass final judgment upon its value to support traffic. The work carried on by our survey covered nearly 500 samples of gravel, taken at points which represent all the leading geological conditions. A comparison of the laboratory results was made with the count of the stones in every case.

The test used was the Rea modification of the standard Devel abrasion test, which modification consists

in the addition of six steel balls, used as an abrasive. For the bed-rock, the standard Devel test was carried on. The actual figures obtained was of course different but the relation between the two tests were similar. In other words, if we found that a certain bed-rock showed a high per cent. of wear when tested by the standard method, we should expect a similar high per cent. of wear using the modified test on gravels composed chiefly of that type of rock.

As a result of the investigation, the State Highway Department has adopted the following as a specification:

General—Gravel shall be composed of fragments of hard, durable rock, the individual particles showing reasonable uniform resistance to abrasion, together with sand or clay or other binding material.

Physical Properties—The gravel shall meet the following requirements:

Class A gravel—Per cent. of wear not more than 7
Class B gravel—Per cent. of wear 7-10
Class C gravel—Per cent of wear 10-25
Class D gravel—Per cent. of wear . . . Over 15

Class A and B gravels may be used for either or both base and surface courses; Class C may be used for base course only; and Class D may be used on special written permission of the commissioner.

This specification is applicable to our conditions. It has been devised after noting the actual road making values of various gravels. It is purely arbitrary, but are limits which we can meet in New Hampshire, but it is appreciated that these values may not be feasible elsewhere.

Someone has remarked that if given an Italian and a shovel he would find more gravel than a geologist could. Reason and experience indicate however, that both the shovel and the geological understanding are essential to any thorough and economical search for gravel. One illustration is perhaps enough. In a certain New Hampshire town, where new road construction was contemplated several years ago, a new gravel pit, located by simple, practical methods, was purchased and opened by a street railway company. It was located on a road corner, on a flat plain, on the outskirts of town. Knowing that gravel was actually in sight, and assuming quite correctly, that the deposit extended as far as the plain itself, the agents of the town purchased a small tract on the opposite corner, and prepared to develop a gravel pit for road material. Soon after this purchase had been effected, the deepening excavation of the street railway company's pit disclosed the fact that gravel was limited to the topmost three or four feet of the plain and that beneath that it was all sand. The town pit, accordingly has never been opened. It is true that sinking of test holes to a greater depth than is usual might have prevented this poor investment of town funds; but it is also true that the shallowness of the gravel deposit could have been foretold by anyone acquainted with the geological history of these broad washplains. Such knowledge is so easily acquired that it is absurd to ignore the practical value of it.

There can be no question of the value to any highway department of a detailed survey of road materials. If the material in any deposit proves to be inferior, it stands to reason that there is a cause for the inferiority. The thorough knowldege of these causes, whether they are conditions of bed-rock or glacial geology should be obtained. For this, the employment of a competent geologist is absolutely necessary. No well organized testing laboratory should be without one.

The testing laboratory should become a clearing house of information to which the engineer may refer, as often as new construction projects call for the selection of material anywhere in the state. Turning to the colored geological map the engineer sees at once whether the conditions of bed-rock and glaciation are such as to favor the occurrence of strong or weak gravels. Colored pins on the map tell him the location and general quality (in terms of strength) of all samples already collected studied from that district. A number on each pin indicates the laboratory test number of that sample. Reference to the files to the cards bearing these numbers affords the more exact record of the stone counts and the abrasion tests. These facts enable the engineer to turn in the right direction in his search for gravel, avoiding loss of time through search where gravels are weak and looking rather for banks where stronger gravels must be expected. If his own knowledge of occurrence of gravel deposits there is incomplete, he may call in the geologist for consultation or for a special field reconnaissance. In this way, the best sources will not be overlooked. Samples are then collected from the more promising banks. Finally, the tests run on these samples by the laboratory will mainly determine the choice. Questions of amount available, relative economy of operating different banks, etc., will be left to the highway engineer and the administration officer. In short, the process of discovery and selection of gravel is scientific instead of haphazard.

UNIVERSITY OF ILLINOIS SHORT COURSE IN HIGHWAY ENGINEERING

The ninth annual short course in highway engineering will be held by the Department of Civil Engineering of the University of Illinois, Urbana, on Feb. 20 to 24. Especal attention will be given to county road problems, particularly those arising under the laws passed by the last session of the state legislature, which have added greatly to the powers and duties of the counties.

The Division of Highways of the Illinois Department of Public Works and Buildings is actively cooperating in the work of the short course and many of the engineers connected with the Division of Highways will make addresses.

The sessions are open and there are no fees charged.

Uniform Legislation as Affecting Highway Traffic and Highway Transport*

By D. C. FENNER†

Any discussion and understanding of uniform legislation as affecting highway traffic and highway transport must be based upon a thorough knowledge of the political structure of the governmental units in which highway traffic and highway transport prevail. This observation seems almost axiomatic and perhaps superfluous, yet too often in voicing the desirability and need for uniform motor vehicle legislation we overlook the fact that motor vehicles in their operation pass through the border lines of and come in turn under the jurisdiciton of municipalities, counties and states.

As for municipal control over highway traffic and highway transport, the kind and degree of such control is dependent either upon the constitutional rights which any state may give to its municipalities, or else upon the laws which states have enacted delegating more or less of their own power on the subject to some or all such municipalities.

While it is true that as a general rule the municipalities may not enact ordinances regulating highway traffic and highway transport along lines in conflict with the provisions of the general state motor vehicle laws, nevertheless, there are numerous important exceptions to this rule. Then, too, there are matters such as the regulation of motor vehicle operation in front of schools, churches, and on fire streets, etc., which are matters of local concern and are usually left to the municipalities for regulation.

By a process of elimination, therefore, we arrive at the fact that under present conditions ultimate control in the matter of legislation governing highway traffic and highway transport lies in the legislature of our various states. It is to these state legislatures, therefore, that in last analysis we must look for that vital and important and—namely, uniformity of motor vehicle laws and uniformity of enforcement.

Uniform legislation does not mean, necessarily, that all states should adopt one and the same law, identical in all their provisions. This might be consdered the ideal condition, but from a practical standpoint, it is not necessary.

What is needed, however, is uniformity in those sections of the state laws that deal with definition of terms, traffic regulations, hand signals, qualifications for drivers, size and weight restrictions, obligatory equipment of a vehicle, headlight law, the denominations and disposition of license fees.

Let us take a specific instance to illustrate this point. From the standpoint of the trucking business, which is today assuming very large proportions, no factor is more important than that the various states and their political sub-divisions should impose one and the same set of rules and regulations governing the weight limits which such trucks are allowed to carry. A very encouraging procedure in the states of Connecticut and New Jersey restricts the load upon a motor truck to the manufacturer's rated capacity of the vehicle. As the enforcement of this provision will absolutely prevent overloading, it gives the manufacturers a chance to cooperate with the state highway engineers in the design and proper rating of vehicles for the protection of the highways.

The standard specifications for a motor truck chassis now contains the allowable gross weight of the chassis, body and load, and alo the actual chassis weight. It is possble that these two weights will be the only ones stamped on the truck caution plate by the manufacturer, and that the actual weight of body and the resultant pay load capacity must be stamped on the plate by the owner of the truck before he can obtain his vehicle license plates. Similarly in the operation of passenger cars there are virtually as many laws on the subject of head lamps and head lighting as there are states in the Union, and no one starting out on a tour is able to be sure that perhaps at any moment or at any place he will not be arrested and severely penalized for the breach of some law or regulation at variance with the ones of his own state with which he is familiar and whose observation has become a matter of habit.

This wide variation in state vehicle laws and the unsatisfactory conditions resulting therefrom are greatly aggravated when there are local ordinances additional to or at variance with those laid down in the state laws. Obviously, therefore, the commercial operation of a motor vehicle, even within the confines of a state becomes more or less of a gamble.

The remedy for those unsatisfactory conditions lies, of course, in uniformity of state laws having to do with the operation of motor vehicles and uniformity in county or other municipal ordinances. Furthermore, the local ordinances must in every respect conform to the general principles set forth in the uniform state law. Several movements to accomplish this end have been begun, but the one which has attracted the most support and has gained the greatest headway is that which is now being sponsored and furthered by the Motor Vehicle Conference Committee, an organization composed of representatives from the American Automobile Association, Motor and Accessory Manu-

*Paper presented at the Nineteenth Annual Convention of the American Road Builders' Association.

†Manager, Public Works Department, International Motor Company.

facturers' Association, National Automobile Chamber of Commerce, National Automobile Dealers' Association of America, and the Trailer Association of America. Their views on the matter of uniform state legislation are set forth in a so-called proposed Uniform Motor Vehicle Law and Proposed Uniform Anti-Theft law. To be sure, those measures contain many features to which persons have taken exception, and it is quite possible to point out sins of commission and omission in their provisions. Nevertheless, their recommendations reflect the views of able and experienced men in matters having to do with highway traffic and highway transport, and it is gratifying to know that many of the recommendations of these two proposed laws are finding their way, if not verbatim, at least in principle, into many of the laws of our various states.

More important, however, than this is the fact that the extensive and intensive work that has been done in advocating the proposed Uniform Vehicle Law and Proposed Anti-Theft Law have brought home to the public and their law makers the fact that the time has come when uniformity in the regulation of highway traffic and highway transport is absolutely necessary for the safety and convenience of vehicular and pedestrian traffic. In consequence, I bespeak your interest in and strong support for every movement throughout the United States which has this end in view and based upon specific principles of fairness and justice to all concerned.

The Road in Verse

The following, credited to Ernest Kidder, was quoted by P. E. Doolittle, President of the Canadian Automobile Association, in the course of a paper entitled, "The King's Highway," presented at the last meeting of the Michigan State Good Roads Association at Flint:

Deductive History

The manners, methods and modes
Of building Caesar's Roman roads
Are hidden by their early date,
And archaeologists debate,
In terms unmeaning to the mob,
Just how old Caesar "done the job."

But there are certain episodes
Linked with the paving of these roads
Which any half-way occult eye
Can see at once, if it will try.
For instance, Casca (jealous brute!)
Inspired an injunction suit.
The Knocker's League of Southern Gaul
Just couldn't stand for roads a-tall;
The village merchants were afraid
Good roads would hurt their local trade.
Of course they couldn't meet the terms
Of those mail order Roman firms.
The legislation was delayed
While Brutus urged a change of grade,
And Cassius called it a disgrace
To have his pretty country place
All littered with a greasy bunch
Of Tuscan workmen eating lunch.
He swore because they would not let
Him drive before the grout was set,
And Caesar, worried half to death,
Was called a grafter with each breath.

But these unpleasant episodes
Stopped with completion of the roads.
Young bloods, from Rome to Brittany,
Went joy riding twice a day;
The merchants in the far backwoods
Put in a line of chariot goods.
The farmers worked a whole lot less
And one and all they rose to bless
Friend Julius. And the folks in town,
They offered him a kingly crown.

Later in the paper, in describing English road conditions in the latter part of the 18th century, Dr. Doolittle quotes the subjoined verse, said to have been written by Robert Burns after the completion of a long and tiresome journey:

I've arrived at last, thanks to the gods,
O'er highways rough and muddy,
A certain sign that making roads
Is not this people's study,
And though I'm no on Scripture learned,
I'm sure the Guid Book says
That heedless sinners shall be damned
Unless they mend their ways.

LARGE ROAD MILEAGE BUILT LAST YEAR

Eleven thousand nine hundred and thirty miles of Federal-aid roads were constructed under the joint supervision of the Federal Government and the States during 1921, according to reports of the Bureau of Public Roads of the United States Department of Agriculture. Federal money amounting to $94,057,089 was alloted to these roads, the total cost of which was $231,963,682. In this mileage there is included 8,595 mi. in projects wholly completed and the equivalent of 3,335 mi. of work done on projects which are not wholly completed. Every state shared in the benefits of this work.

The projects under way during the year amounted to 31,228 mi. which was about one-half of all the road work carried on in the United States during the year. A fair idea of the magnitude of the road work done under the supervision of the Department of Agriculture last year may be gained when it is undersood that the total mileage is considerably more than enough to encircle the earth, that it is equal to more than 10 per cent of all the improved roads previously existing in the United States, and that it is equal to nearly eight per cent of the entire road system of France. At this rate we would be able to build the equivalent of France's entire road system in 12 years.

ROAD INFORMATION HARD TO OBTAIN

With the annual expenditure for roads and streets in the United States approaching the billion-dollar mark, more accurate information and better means for obtaining it seem necessary, says the Bureau of Public Roads of the United States Department of Agriculture. One thing very much needed is the concentration of all sorts of information and statistics concerning the roads of the various states in the state highway departments.

Engineers of the department are now gathering complete information regarding the road mileage and expenditures in the United States. In many of the states

much of the information desired is easily obtainable from the state highway department. In the case of Iowa the figures were obtained almost immediately. In other cases it has been necessary to send out numerous questionnaires and sometimes the information has been obtained only after personal visits. In one state 1,800 questionnaires had to be sent out to bring in the needed figures, and in some it has been found that practically no records have been kept. For some of the counties in New Mexico questionnaires had to be translated into Spanish before the road officials could understand them.

MEETINGS

Calendar of Coming Meetings

Feb. 12-17—Conference on Highway Engineering.—Eighth Annual Conference, University of Michigan, Ann Arbor, Mich.

Feb. 21-22—Kentucky Association of Highway Contractors—Annual meeting, Louisville, Ky. Secretary, D. R. Lyman, Louisville, Ky.

June 4-6—American Association of Engineers—Annual convention, Salt Lake City, Utah. Secretary, C. E. Drayer, 63 E. Adams St., Chicago, Ill.

June 26-July 1—American Society for Testing Materials—Twenty-fifth annual meeting, Atlantic City, N. J. Secretary, C. L. Warwick, Engineers' Club Bldg., Philadephia, Pa.

FURTHER FEDERAL AID URGED BY WASHINGTON CONFERENCE

Coordination of the three major forms of transportation so that railways, waterways and highways may each carry the kind of traffic that it can most economically, expeditiously and efficiently serve was urged by President Harding's agricultural conference held recently in Washington.

Country highways, declared the agriculturalists, are the farmers' first and principal means of marketing their products. They are, it was declared, the arteries of the economic and social system of the country and on their condition rests the amount of transportation charge that must be added to the gross cost of farm products.

The attention of the country was called to the heavy losses now sustained by farmers on account of bad roads and to the economic and social benefits which accrue to them and to the people of the whole country as a result of general road improvement. The conference declared that farmers ought to be able to haul to markets twice as much and twice as often as he has been able to do so in the past and that if the farmer is to help influence the price of his products by not dumping them on the market for fear of unseasonable weather, he must control the condition of the roads to his markets.

To bring about the general improvement of highways and to facilitate the farmers' marketing problem, the conference went on record as being in favor of highway research by Federal, State and college authorities to the end that traffic on highways may be regulated according to the facts developed.

Congress was urged to continue Federal aid for the building of interstate, postal and the farm-to-market roads and to appropriate adequate funds for a definite period so that the states may plan equitable cooperation.

The conference urged that every possible effort be made to promote safety of life and limb on the highways and that as economy of transportation depended on well-kept highways that all possible safeguards should be placed about the maintenance of the roads.

Realizing that traffic conditions are rapidly changing and that road building is now an important engineering and business undertaking, the conference urged that all partisan or political considerations in such work must be eliminated.

PERSONAL MENTION

Maurice L. McKenna, formerly city engineer of Bridgeport, Conn., and for the past four years superintendent of construction for that city, has resigned.

Col. James Milliken has been elected president of the Pittsburgh Testing Laboratory, Pittsburgh, Pa., succeeding Geo. H. Clapp, resigned.

William Ord has resigned as manager of the paving department of the Lakewood Engineering Company, Cleveland, O.

W. A. Alexander has been appointed district engineer for the Portland Cement Association, with headquarters at Helena, Mont.

A. C. Love has resigned as division engineer of the Texas State Highway Department and has been appointed county engineer of Jefferson County, Texas.

OBITUARY

Walter A. Cook, vice-president and general manager of the Acme Road Machinery Company, Frankfort, N. Y., died at his home in that city on Jan. 23. Mr. Cook was one of the pioneer manufacturers of road machinery in this country.

John A. George, formerly City Engineer of East Liverpool, O., died recently at the age of 82 years.

GOOD ROADS

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TABLE OF CONTENTS

*Minnesota Builds Roads Under Babcock Plan . 107

Asphalt Specifications—Past, Present and Future. By Larcy M. Law 111

The Business of a Highway Commission. By C. M. Upham 114

The Use of Local Mineral Aggregates in Bituminous Macadam Roads. By W. A. Welch 117

Road and Bridge Work in Manitoba 118

Road Work in South Carolina 119

Montana Concentrates of Gravel Roads 119

Road Building Has Grown to Prominent National Industry 119

Effect of Moisture on Concrete 119

Status of Federal Aid Road Completed by States . . 120

EDITORIALS:

Continued Federal Aid 115

Road Work in Minnesota 115

Soldiers' Bonus and Good Roads 115

Asphalt Specifications 115

MEETINGS:

Calendar 120

*Illustrated article

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THE HIGHWAY CONTRACTOR AND ROAD BUILDER

Vol. LXII NEW YORK, N. Y., FEBRUARY 22, 1922 Number 8

Minnesota Builds Roads Under Babcock Plan

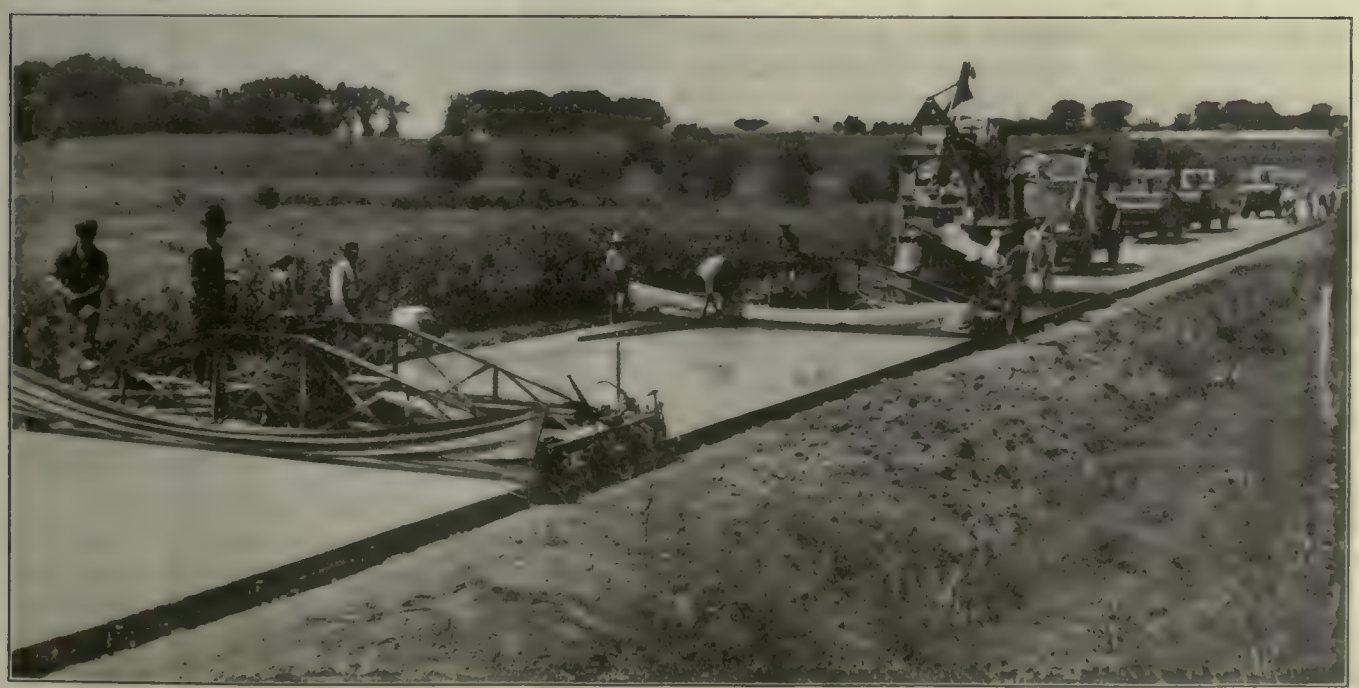
The Babcock plan of highway development in Minnesota is attracting wide attention, partially because of results during the first six months of operation. Graded and gravel surfaced mileages on Minnesota's primary system of highways have been increased 40 per cent and the paved mileage has been almost doubled, over improvements listed when it was transferred to the state. Relieved of the expensive burden of arterial highway construction and upkeep, counties and towns have more funds available for use on the secondary system or feeder roads.

State Highway Commissioner Babcock indicates confidence that with public interest and support continued, Minnesota within comparatively few years may advertise to the world a complete system of adequate highways—may add good roads to its ten thousand lakes, virgin pine forests and other attractions upon which rest its claim to recognition as America's summer playground.

The Babcock plan was brought out by rapidly increasing motor vehicle traffic, which demanded modern roads as it wore out the old turnpikes. Counties and towns were spending every dollar available to keep main roads passable under the growing grind of heavy, high-powered cars and secondary roads were more or less neglected. The necessity of providing adequate roads was generally recognized; nevertheless, increases in road tax levies were opposed.

Commissioner Babcock presented his plan.

"Let wheels using the highways pay a fair share of road improvement and upkeep expense," he proposed. "Put a heavier tax—the average was $10.60



VIEW OF CONSTRUCTION WORK ON ROAD BETWEEN ST. JAMES AND MADELIA, MINN.

a year, including the license fee of $5 for three years—on each automobile and truck and use the proceeds to build up and maintain the trunk highways. Good roads will enable car owners to save more than the tax on repairs, tires, gasoline."

The automobile owners favored the idea. Engineers' test had demonstrated big savings possible in the operation of motor vehicles on good roads over poor roads. Motorists wanted good roads.

"Use the motor vehicle tax revenue and Federal highway aid on the trunk roads," Commissioner Babcock continued. "Leave the counties and towns all local tax funds and state highway aid for the secondary or feeder roads. Without the expense imposed by the main highways, they will be able to adequately improve and maintain the feeders. It is primarily a farm-to-market roads plan."

Farmers, too, favored the plan as it was understood, business and professional men and other citizens fell into the line. Good roads represented an urgent need.

Pioneering for Good Roads

Charles M. Babcock was a merchant and associate in various enterprises in the picturesque town of Elk River, 40 mi. north of Minneapolis and St. Paul. Bent upon extending the trade territory of the town, he had been instrumental in effecting improvement of a road. The result exceeded even his own best expectations. It demonstrated that farmers would drive many miles over a good road rather than a few miles over a poor road to a trading-point. Business increased accordingly in Elk River, at the end of the better road.

Mr. Babcock undertook other like projects which further established the tremendous value of good roads. He found the hobby fascinating and was impressed with the great possibilities offered by adequate highway development in the North Star state. He was prevailed upon then to accept a commissionership on the state highway board.

The Minnesota Highway Commission was created in 1905 and George W. Cooley, now deceased, was appointed state highway engineer. He spread the good roads gospel with the assistance of Robert C. Dunn, country newspaper editor, state auditor and senator, who died just before Mr. Cooley, and of John H. Mullen, now deputy commissioner and chief engineer of the highway department.

Senator Dunn sponsored the bill for the constitutional amendment which created a state highway aid fund with the proceeds of a 1-mill general tax and was designed to help counties with comparatively low assessed valuations to keep fairly up to the road improvement pace set by the "richer" counties.

Put on Business Basis

Public demands for better highways became more and more pressing. Funds were insufficient to meet them. Under the state constitution, highways were improved and maintained solely by counties and towns, the state was without authority to spend a single dollar, were it available, on actual highway work.

Roads in Minnesota, as in other states, were years behind traffic demands and going steadily backward. The county system on arterial routes brought patchwork development to emphasize the need of state control of inter- and intra-state arteries.

The Minnesota Legislature of 1919 submitted to popular vote, at the following general election, Good Roads Amendment No. 1, proposing to effect the Babcock Plan.

First, the amendment proposal was to create and establish a system of trunk highways to be constructed, improved and maintained forever by the state. Specified routes approximated 7,000 mi. and connected county seats and important towns of every section, and also the famous ten thousand lakes, and other recreational regions. Additions would be permitted upon completion of 75 per cent of the mileage.

SUPERELEVATED CURVE ON MINNESOTA TRUNK HIGHWAY

Secondly, the state trunk highway fund was created to finance trunk system operations. It included federal aid allotments and the proceeds of a more onerous tax on motor vehicles using the highways, in lieu of personal property and other levies except city wheelage taxes. A further provision was for the authorization of trunk highway bond issues to run not to exceed 20 years and to limit to $75,000,000 the amount that might be lawfully outstanding at any one time.

Borrowed Funds Being Used

Borrowed funds are being used on the trunk system, although the state has issued no highway bonds. To insure against cessation of work by counties on the trunk routes in anticipation of adoption of Amendment No. 1, the Legislature of 1919 also authorized counties, under certain restrictions, to issue up to $250,000 each of bonds, proceeds to be expended on the trunk

highways, and virtually pledged reimbursement by the state. Many counties acted under the law.

Adopted by Huge Majority

Good Roads Amendment No. 1, carrying adoption of the Babcock Plan, was passed Nov. 2, 1920, by a vote of 526,936 to 199,603. The big majority was attributed in part to an educational campaign in which the newspapers of the state took an important part, and which was directed by the Minnesota Highway Improvement Association.

The association was a semi-public corporation formed by state officials and good roads advocates and included representative citizens in every locality in the state.

Making it the people's fight for adequate highways, the association obtained funds by popular subscription. Contributions came from commercial and civic organizations, farmers' clubs and hundreds of individuals. County doctors driving on difficult roads,

TRAFFIC DIRECTION SIGN ON MINNESOTA HIGHWAY

periodically raised their subscriptions, as did others toward making more certain the adoption of the good roads amendment.

Less than $100,000 was raised and used by the association—the total being relatively smaller than the amounts employed for like campaigns in other states. A bureau of speakers was organized and millions of pieces of literature were circulated. Virtually every newspaper in the state gave columns to the plan and many solicited funds to run display advertisements at reduced rates.

Legislature Ratifies Amendment

The Babcock plan was made effective by acts of the Legislature of 1921.

Motor vehicle tax schedules were given extensive study by legislative committees. Rates finally adopted were based upon factory list prices with depreciation allowances of 25 per cent for 3 and 4-year-old machines, and 50 per cent on cars 5 years old or older.

The passenger car rate is 2 per cent with a $12 minimum, and the trunk rate 2¼ per cent, $15 minimum. The average was estimated at less than $20 a year. Dealers are assessed $25 a year for licenses and charged nominal fees for extra license plates for cars which can be used lawfully only for actual demonstration purposes. Dealers in used cars must pay regular rates on cars remaining in their possession after November 1. Taxes for the last six months each year are at half rates. Penalties attach for delayed payments. Motor vehicle taxes are collected and license plates issued by the secretary of state.

General highway statutes were completely recodified to correlate new sections with those affecting the local highway authorities. The measures were passed with big margins in both branches of the legislature.

Highway Program Speeded

Governor J. A. O. Prues signed the bills April 25 and announced the reappointment of Commissioner Babcock under the new laws effective immediately.

Commissioner Babcock named Mr. Mullen chief deputy and highway engineer. Experienced men already identified with the department were retained, and the list included J. T. Ellison, bridge engineer, W. F. Rosenwald, maintenance engineer, O. L. Kipp, construction engineer, and F. C. Lang, engineer in charge of tests and laboratories.

From the small nucleus, a greatly enlarged administrative force was built up. County road engineers, familiar with local conditions in various sections were added to the staff, filling the positions of eight division engineers and sixteen district maintenance superintendents. Offices of the highway department spread to spaces on six floors of a St. Paul building; then a capitalist friend offered to erect the department a home which is nearing completion now.

Effective Maintenance First

"The first move must be toward putting and keeping every part of the 7,000-mi. trunk system in good, passable condition," Commissioner Babcock ordered. Immediate steps followed to put into the field a maintenance force organized along lines worked out several years previously.

The purpose was to extend early benefits to every locality of the state by providing a constant-duty patrolman for each 5 mi. section of the trunk highway system. Every patrolman must live on or near his "beat" and furnish his own team or tractor, grader, drags and other tools. The going wage is paid the patrolmen and they receive an allowance for rental of equipment, the latter method being adopted to insure better care of tools.

More than 1,200 patrolmen were covering about 6,200 mi. out of the 7,000-mi. system within sixty days, according to official records. In some cases the patrolmen worked to disadvantage at the start because of poor foundations, and state fleets of heavy outfits were ready to help them.

War Equipment in Service

Fleets were made up of 50 tractors and 150 trucks, part of the surplus war equipment turned over by the U. S. Bureau of Public Roads. The trucks were overhauled and fitted with hoist bodies for handling gravel, and the trucks converted to constructive work, in big machine shops maintained by the highway department on the state fair grounds.

Extensive use of heavy machinery made a sharp demarcation between the old and new methods on trunk highways. The combined equipment was found equal to dressing up roads at the rate of 5 mi. a day. The tractors drawing heavy blades would shape up and make a good wheel track and the trucks follow on to add a surfacing of gravel.

New construction projects were undertaken with the maintenance plans well started.

New construction projects were listed by the executives in the field. Orders were wired to St. Paul headquarters. Survey parties were rushed out in all directions to procure necessary engineering data. When undertakings were ready and estimates at $1,000,000, the group was advertised for bids and wide competition was obtained.

The low bids were most reasonable, engineers announced at the time. Paving was contracted as low as $28,300 a mile, while other states were reported fighting for proposals under $30,000 a mile without success. Correspondingly low figures were secured on grading and gravel surfacing, ranging from 40 to 50 per cent. under those paid by counties the year before and almost back to pre-war levels, it was stated.

Operations in Full Swing

As in the maintenance department, in the construction department progress charts on July 15 showed contract jobs under way on a large scale. Nearly 75 projects running well above $5,000,000 were going forward in almost as many widely distributed sections of the state.

One big handicap was forced curtailment of the program for the first regular season. The state legislature had authorized no issues of trunk highway bonds and federal highway aid was not forthcoming as anticipated.

Reimbursement bonds, previously referred to, had been voted, however, by a number of counties and large balances were available to help the department enlarge the first season operations.

County officials concluded, however, that in any event the state would keep up and gravel the trunk routes, and insisted as a rule that bond money be used for hard-surfacing. This resulted in an abnormal amount of paving during 1921.

Approximately $7,500,000 of reimbursement bond money was used and some counties gained precedence in local improvements on the system.

Funds Exceed $28,000,000

Under the new scheme, Minnesota was using more than $28,000,000 a year for road building and maintenance, against about $16,500,000 maximum under the old plan.

Motor vehicle tax revenues were running up to the $6,000,000 total expected, and with the reimbursement bond money, the trunk funds aggregated $13,500,000. Federal aid later added $2,123,000 to the trunk fund. Counties and towns were furnished more than $12,500,000 for exclusive use on the secondary highway system —about $11,000,000 of local tax revenues and $1,650,000 of state aid.

When the trunk highway system was transferred to the state it was listed with 1,499 mi. graded, 1,371 mi. graveled and 112 mi. paved, the balance being in lesser degrees of advancement and mainly of good dirt roads. Adding 103 miles of hard surfacing, the state department nearly doubled the paved mileage, while the graded mileage was extended by 680 mi. and the gravel-surfaced mileage by 438 mi. all within six months. Also, maintenance forces re-shaped 713 mi. and re-graveled 462 mi.

The expenditures approximated $4,758,026 for grading, $1,605,122 for graveling, $3,549,259 for paving, and $514,047 for bridges, and with the $3,000,000 set aside for maintenance, made the regular season total of $13,426,454 on trunk routes and exclusive of betterments on the secondary road system.

$4,500,000 of Winter Work

A ruling was given by Clifford L. Hilton, Attorney General of Minnesota, that the collection of motor vehicle taxes might lawfully be anticipated to match federal aid. Commissioner Babcock's tentative plan is to use about $4,500,000 on winter work to hasten needed road improvements and prevent forced idleness among workingmen and avert suffering among their dependents.

Bids early in December last year on 44 widely distributed projects estimated at $2,293,500 and covering more than 300 miles were called for within ten days after Congress voted federal aid. Deputy Mullen continued conferences with construction and division engineers to add more jobs to the lists without unnecessary delay.

Heavy excavating with steam shovels, distribution of gravel and other materials predominates the work proposed to furnish jobs for hundreds of men.

Save for actual permanent construction, highway funds are being conserved for heavy traffic season benefits, highway officials explained. Accordingly, snow removal and other winter work is being limited.

Formal opening of the first 100 mi. of continuous pavement on the Minnesota trunk highway system was celebrated last fall at St. Cloud, the northern terminus of the paved way. Speakers took occasion to compliment the highway department on first year achievements under the Babcock plan and plans were reported that the longest continuous pavement another year will be nearly doubled in length.

The importance of adequate highways and the benefits sure to follow them are appreciated in Minnesota.

Asphalt Specifications-Past, Present and Future*

By LARCY M. LAW†

The invitation of your president to discuss today the subject of asphalt specifications recalls an early paper by the speaker on a particular phase of the same subject which was published about eight years ago. That paper discussed the increasing use of specifications in connection with asphalt purchases and also the desirability of specifications as affording the actual basis for competition in prices. Its principal purpose, however, was to call attention to certain analytical requirements then prevailing in so many specifications but which, by reason of their empirical or experimental character, rather tended to defeat the object of a specification.

Eight years, however, is a long interval in these days of improvement and we are proud to say that highway construction has not lagged behind the wheels of progress even though a four years' world war practically put a stop to the industry. Now that constructions are to go forward with perhaps greater energy than ever, it might be well to pause for a moment and consider the status of our asphalt specifications.

With your indulgence, therefore, the present paper will attempt to briefly review past developments and offer, from the producer's standpoint, a few suggestions as to future improvements.

I am sure that I express the sentiments of most refiners in stating that there has been a great improvement in asphalt specifications during recent years and that these improvements have manifested themselves not only in the requirements proper but the methods of testing as well. Let us take up these directions of improvement in the order named.

The early asphalts were the so-called native bitumens—few in number and early specifications simply designated brand or, more strictly speaking, the source of original, leaving to the suppliers and contractors the actual details of manipulation. These materials had to be "fluxed" or softened for paving purposes and, with the extension of the industry, specifications gradually developed. They provided not only for the asphalt but the residuum for fluxing purposes, together with stipulations as to the finished asphaltic cement. Later on as these materials were studied in the laboratory, there were evolved such physical tests as penetration, flow test, melting point, ductility, brittleness, loss by evaporation, flash point, etc. Chemical tests such as solubility in various reagents, petrotenes (naphtha soluble), sulphur, paraffine scale, fixed carbon, etc., were also applied and specifications elaborated accordingly.

Upon the entrance of petroleum asphalts into the market it was, to a certain extent, only natural that these materials were judged in the light of previous knowledge. In some respects they complied with the old standards—in others they did not but practical demonstrations were showing them to answer all the requirements for paving purposes. Such circumstances added further importance to the then discussed question as to what were essential and what were non-essential requirements in asphalt specifications.

Looking back at the early attempts in weeding out the non-essentials, doubtless the greatest factor was our American Society for Municipal Improvements which adopted in 1915 a specification based upon four (4) tests only, namely penetration, ductility, loss by evaporation (and penetration of residue) and flash point. This specification, much as it was contested at the time, has certainly proven itself a safe one for, in essential features, it has been adopted by most of our leading cities and municipalities and has been thus instrumental in securing many miles of the best construction. More subsequent improvements have been in the direction of further specification by basing the requirements on the asphalt cements omitting reference to crude or refined asphalt and fluxes that may be used in their preparation. There is little doubt that this will be the general form of future specifications.

Aside from the four or five requirements now quite generally considered as essential there is of course disposition to still include, in some cases, fixed carbon, paraffine scale and naphtha soluble (or insoluble) and specific gravity. In the various refineries, these are regarded as collateral properties, depending on the particular crude from which the product is made and the extent or consistency to which the refinery process is carried. They have no bearing on service conditions, serve almost entirely for identification purposes and are gradually disappearing from the list of requirements.

Coming now to the improvements in testing, it can be readily understood that specifications made up of numerous requirements involved correspondingly numerous tests for the examination of materials made under them, but unfortunately for a long time even the more essential ones were not standardized.

The penetration test, for example, which has perhaps always been the most important of all the tests for bitumens, was for a long time conducted with great variations in technique. In fact, it seemed to those of us who were compelled to follow such matters, that laboratories were going out of their way to devise new and unheard of modifications. Various types of needles were used instead of the commonly supposed Roberts No. 2 sharps; thermometers were often inaccurate and there was also great variation in the size and shape of the sample container, all of which conditions exerted

*Paper presented at the Nineteenth Annual Convention of the American Road Builders' Association.

†Chief Chemist, New Orleans Refining Co., Inc.

their influence on the test results and the consequent acceptance or rejection of shipments.

Similar conditions prevailed also in the case of the volatilization test wherein a 2½ in. diameter and ¾ in. deep flat bottom tin dish was the commonly understood laboratory utensil for holding the sample. In practice, however, these dimensions were the exception rather than the rule and, since in some cases 20 gram samples were employed, the variation in exposed surfaces was of considerable importance.

The oven itself was also an important factor on account of variations in shapes, sizes and draft, etc., to say nothing of the position occupied by the sample when in the oven—yet few were the specifications which took cognizance of these apparently unimportant features.

Your speaker has also seen the flash point test conducted in all kinds of apparatus from the top of a baking powder can to the most elaborate form of automatically operated closed testers. Bulbs and total immersion thermometers were frequently used interchangeably and the matter of rate of temperature rise frequently ignored entirely. These and many other similar conditions of testing formed the environment under which the asphalt refining industry has been built up and although they doubtless still prevail in numerous instances there has been, in general, a very substantial change for the better.

The American Society for Material through its Committee D-4 has taken the lead in the matter of bringing order out of chaos in those tests for bituminous materials and, since its by-laws require a balance between producing and consuming interests there can be no objection to its activities on the grounds of favoring either party. Its efforts along these lines became particularly noticeable along about the year 1912 and today its 50 members are more active than ever in clarifying these meeting grounds of purchaser and consumer—the asphalt specifications.

In 1911 a standard test for solubility applicable to the various reagents such as carbon di-sulphide, carbon tetra-chloride chloroform, naphtha, etc., was adopted. While perhaps somewhat more elaborate than many forms of the test in routine use, its object is accuracy and applicability to all bituminous materials and only a method of this type should be provided where disputes are liable to arise, such as in the case of specifications.

The standard procedure of 1911 for making the apparently simple penetration test was practically rewritten in 1916, after four years collaborative study and tests by a sub-committee in order to cover important details of technique previously neglected. In 1921 the method was further modified by abandonment of the variable and uncertain cambric needle and the substitution of a cylindrical needle of prescribed diameter and cone taper whose dimensions can be readily verified by any one capable of using a caliper. A definite size of sample container is specified as well as accuracy of the thermometer, time of cooling in both air and water and other previously neglected details of manipulation. A series of collaborative results indicative of the precision of this test has also been published.

There was, of course, a practical suspension of standardization activities during the war period, but, in 1920 and 1921, there were adopted revised standards for determining "Loss on Heating" and melting point or more properly speaking "Softening Point." In the former, the sample tin of the penetration test was adopted as the container and the 50 grams sample of former years reverted to. This simplifies laboratory apparatus and permits a "penetration of the residue" without having to transfer the sample. The variable due to oven construction was happily solved by adopting a revolving disc or shelf adaptable to a great many of the types of ovens already in use. Eight samples may be simultaneously tested and they all pass continuously through the same heat zone or path which may be regulated by a thermometer carried in a similar specimen.

Melting points or rather softening points of asphalts are now determinable under standardized conditions by a perfected form of the old ring-and-ball test. A disc of bitumen held by a metal ring of prescribed dimensions is suspended in water or glycerine and a steel ball of prescribed weight super-imposed. Through the uniform application of heat, this specimen begins to melt or, more properly, soften and when it has fallen a distance of one inch the thermometer indication is taken as the softening point. The standardization of this and the penetration method have been perhaps the greatest contributions towards improvements in asphalt specifications.

The tentative standard for "ductility" brought out last year is practically the same as the old "District of Columbia Standard." It is based on pulling the original Dow form of briquette of one centimeter minimum in cross section at the uniform rate of five centimeters per minute and the temperature for testing is 25 degrees C. or 77 degrees F. This procedure has been in use for many years and there is little prospects of any change in essential features.

I must not neglect to mention also the tentative standard for specific gravity recommended in 1921 and useful for converting tons to gallons and vice versa and then there is also the new flash point test based on the Cleveland open cup. The latter has also just recently appeared as a Tentative Standard but there is every indication of its adoption as an official procedure on account of its simplicity.

All of these improvements in methods have been accomplished within the comparatively short space of some five or six years and, while they have alike benefited both consumer and producer they have been especially helpful to the latter in his dealings with a

number of laboratories. If our complicated and vague specifications of earlier days were due to our scant knowledge of bituminous materials, certainly the excuse no longer exists and it is believed that we are now in a position to have satisfactory specifications made up of a relatively small number of simple requirements and based on recognized standards for testing.

Coming now to the matter of suggestions for future asphalt specifications, I shall take the liberty of approaching this phase of the subject from the standpoint of a refiner. Most engineers and contractors, however, have usually proven themselves to be open to suggestions from producing interests, consequently the following thoughts may be not amiss.

Perhaps the greatest desirability in future specifications is a more general simplification of requirements as brought out in foregoing paragraphs. The four provisions for penetration, ductility, loss on heating and flash point together with, perhaps, solubility in carbon disulphide and carbon tetra-chloride, and softening point in the case of fillers, are serving the needs of many large cities and state highway departments and there is no good reason why they should not serve everywhere.

Methods of tests, preferably the above standards, should accompany all asphalt specifications or suitable references should be made therein so that the refiner will know not only what properties are desired but how they will be determined. As a matter of fact, methods of testing are as vital parts of specifications as the actual requirements yet in most cases this does not appear to be realized.

Another suggestion—and one that I make with considerable delicacy—is that we should have just a little more competent inspection of deliveries for the refineries are frequently the victims of inefficient and even careless testing. In this connection improper sampling, overheating of the specimen by too hasty melting and the use of contaminated containers have frequently been found responsible for discrepancies. Sampling as well as testing should, therefore, be conducted only be experienced persons. Refinery laboratories are equipped with the latest improved apparatus and employ high grade technical operatives. While occasional errors are, of course, possible with all human agencies, the chances for increased shipments are few under modern methods of refinery control.

Before closing this paper, I desire to call your attention to the narrow limits for consistency or "penetration" of paving asphalts which are now being ordered and ask your cooperation in remedying what has for some time been quite a troublesome matter. It is not by any means expected that we can accomplish at once a standardization in this respect for certain engineers have more or less fixed ideas regarding the subject and successful business necessarily requires that cutomers shall be satified. At the same time, however, we must look at the general situation. There are two reasons why asphalt penetration limitations should not be unduly restricted and, in view of the fact that they are not generally understood, these reasons are presented more or less in detail.

In the first place, although the penetration test itself has now become fairly well standardized as stated, it is by no means a test of great precision as some are disposed to consider it. A three-point difference between two operators working in the same laboratory is quite permissible as being within the limit of experimental error and, since such a difference may be in either direction a six-point permissible range is thus justified.

Under the circumstances, a specification allowing a ten-point range actually restricts the refinery to four points or degrees in penetration which is perhaps sufficient but only so under the most rigid control of manufacturing conditions. For similar reasons five-point limitations are manifestly severe and only possible to comply with where both the seller's and purchaser's laboratories work to a degree of precision that is not warranted by the accuracy of the test itself. Furthermore, orders calling for definite consistencies such as "50 penetration asphalt," "60 penetration asphalt," etc., obviously do not allow even for the experimental error of the laboratory and are practically impossible to fulfill.

In the second place, narrow penetration limits have come to mean a multiplicity of products which in turn involve much unnecessary elaboration of refinery equipment. Like our friends of the brick industry, we cannot economically run our plants like the pickle factories and we should be permitted to discontinue a few of our varieties. If not, the refiner must use elaborate equipment or be continually changing his operating conditions with a resulting loss in plant capacity. These conditions are reflected either in increased manufacturing cost or delayed shipments—sometimes both—with no benefit other than the satisfaction of an exaggerated idea of accuracy. We do not believe that many engineers will contribute to such conditions once the facts are fully explained.

In line with the foregoing statement, some refineries are endeavoring to standardize their paving asphalts as far as possible and, at the same time, take care of the well established types of construction. Under such an arrangement reasonable quantities of several grades such as 40-50, 50-60, 60-70 penetration, etc. could be kept in stock available for prompt shipment.

This policy is entirely in line with specifications of the United States Office of Public Roads and many cities and municipalities. It is also in accord with the recent action of the American Society for Testing Materials which, in proposing six "classes" of asphalts for paving purposes, allows similar penetration limits. Many purchasers, we are glad to say, are already in harmony with such arrangements but a small minority prevents them from realizing the full advantages.

The Business of a Highway Commission*

By C. M. UPHAM †

The title of this paper would suggest the question, "What is the purpose or function of a highway commission?" While an elaborate and complicated definition would be a justifiable answer, it can also be answered by the very simple, clear and concise definition. Regardless of the size of a state or a country commission, the functions of this body are the same: notwithstanding elaborate office buildings, multiplicity of equipment, or number of individuals connected with the commission, still the purpose and function are the same, and the whole can simply be described:

The business of a highway commission is to act as an agent for the taxpayers, for the best economic purchase of roads that can be maintained at a minimum cost, and at the same time, furnish to the taxpayers satisfactory means of transportation, whereby traffic may operate at a minimum of expense.

It is the taxpayers who assemble and decide to buy roads. It is the taxpayers who raise money for the purchase of roads, and it is the taxpayers, through their legislators, who vote bond issues for the purchase of roads, and lastly, it is the taxpayers who pass the laws that create a highway commission to represent them and purchase from contractors or individuals roads for the purpose of founding means of communication, at the lowest cost of operation to traffic. Although the business of a highway commission consists of turning a completed road over to the taxpayers, there is much work necessary and many details must be completed before the finished road is delivered.

It sometimes happens that a highway commission represents a county; if that be so, then its function is to locate and purchase roads that will serve in the growth and economic saving of the county. It generally happens, however, that a highway commission represents a state, which makes it necessary that all county lines must be forgotten and the roads located and constructed where the results will afford means of transportation for the state at large without regard to county boundaries; the roads must be located and constructed so that the state will be able to maintain at reasonable cost the means of transportation that, at low expense, will make possible a healthy development in the state, both industrially, commercially and socially.

The business of settling the alignment of roads is one which if not one of the most important, is one of the most difficult, for a road perfectly constructed, if improperly located, is as bad as a road well located and poorly constructed. It is truly said that the alignment of a road is the only part which is permanent, and if this principle is valid, surely it is the business of a highway commission to so locate that road that it will be to the greatest economic advantage to the most people.

The highway commission must secure all information regarding the alignment of the road, taking into consideration the use of the road; whether it is to be commercial, industrial, or scenic; whether it is to be an all-year road or a seasonal road; whether it is a through road exclusive of local conditions, or whether it can be termed a local road, or a combination of the two; whether the road is for the development of the country, or whether the country has developed to the extent that the road is being constructed merely to lessen the cost of operation of its commerce; the number of people that it may serve; the tonnage which is expected to pass over the road; the construction and cost details of the road relative to its drainage, maintenance; the use of local materials must be studied and all these facts must be taken into consideration, and deliberately considered before the final location of the road decided upon.

To locate, purchase and operate a road means that a commission must have certain data to assist in its deliberations; this is secured by the engineering organization that furnishes to the commission all facts that are necessary to carrying on the business of purchasing and operating roads.

With the aid of the engineering staff, the commission may complete its work and conduct its affairs with the same integrity and principles as an individual business or a larger corporation.

In addition to securing all engineering facts, the commission should make no purchases of roads before it has acquainted itself with the condition of the financial market, taking advantage if possible, of the proper market in the disposal of its bonds, or for buying its materials or roads on a low market. By studying the situation and purchasing and contracting on a favorable market, will mean the saving of large amounts of money for the taxpayers.

It is also necessary after studying the facts, to decide just what is the best method to follow in the purchase of roads, whether it should be by state force account, convict labor, lump sum contract, or unit item contract, or a combination of them.

Regardless of the method selected, it is the business of the commission to see that the most economic road is purchased and that the road purchased is the road delivered and here again it depends on the engineering department for this assurance.

The machinery of road purchasing is similar, regardless of the size of the purchase, or the size of the purchaser. The size of the machinery will, however, vary

(Continued on page 116)

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†State Highway Engineer of North Carolina.

GOOD ROADS

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CONTINUED FEDERAL AID

Hearings are being held on the bill introduced by Representative Woodruff in the House, providing for the appropriation of $100,000,000 annually for a period of five years for federal aid highway construction. As pointed out in last week's issue, the President has signified it as his wish that not more than $75,000,000 be appropriated annually.

One of the great handicaps to state highway departments is their inability to plan very far ahead because of the uncertainty of highway appropriations. Last year a federal aid appropriation of $75,000,000 was passed late in the spring. Highway departments were not justified in laying plans in advance of the appropriation, neither do they now have anything definite for the future to work upon. At one time last year, because of the activity of a certain senator in opposing road appropriations, it was thought that Congress would adjourn without making any provision for federal aid.

With the new highway law in effect providing for the improvement of seven per cent of the highways of interstate importance, the states may go ahead with their plans if Congress makes adequate appropriations for federal aid for a period of years. Efficient engineering organizations can not be built up one day and disbanded the next; yet many state highway departments have been obliged to build and disband their organizations because of the uncertainty of federal aid appropriations. The Woodruff bill ought to be passed without reduction either in the amount of appropriation or the period over which federal aid is extended.

ROAD WORK IN MINNESOTA

The State of Minnesota has joined the list of progressive states that have awakened to the importance of developing their transportation facilities and now highway construction is being carried on in Minnesota on a grand scale. In 1920 a good roads amendment to the constitution was passed by a large majority. Under this amendment a 7,000-mi. primary system of highways was laid out for improvement and the issuance of $75,000,000 of state highway bonds was authorized. Counties are also permitted under the new law to issue up to $250,000 of bounds to finance work on trunk highways, to be later reimbursed by the state. Such arrangement enables road work to be carried on more easily than were the state obliged to market its bonds immediately. Motor vehicle fees have also been increased so that the work can be financed by the use of motor vehicle and federal aid funds, together with the proceeds of a 1-mill general tax which goes for a state aid highway fund to help counties of low assessed valuations.

THE SOLDIERS' BONUS AND GOOD ROADS

In casting about to find sources of revenue to meet the proposed soldiers' bonus, a few federal legislators have suggested the placing of federal taxes on motor vehicles and gasoline. This proposal is being vigorously opposed by the American Automobile Association of State Highway Officials. These organizations are not opposing the bonus but are attempting to forestall the shifting of this tax to the highway field.

At the present time a number of states are securing most of their road revenue from motor vehicles and about a dozen states have enacted a tax on gasoline. It is quite probable that other states will soon levy taxes on gasoline to secure increased road revenues. If federal taxes are placed upon gasoline and motor vehicles serious problems will arise in connection with financing road work in various states. Since motor vehicles have a very direct relation to road construction, it is manifest that any taxes imposed upon them should be used for highway work. Further, if both state and federal taxes were imposed upon motor vehicles and gasoline, the automobile industry would be taxed greatly in excess of any other industry.

ASPHALT SPECIFICATIONS

Some specifications for asphalt now being used are impractical, points out Larcy M. Law, Chief Chemist of the New Orleans Refining Co., Inc., printed elsewhere in this issue, in that they call for penetration limits which are no greater than the limits of experimental error. "Like our friends of the brick industry," says Mr. Law, "we can not economically run our plants like the pickle factory and we should be allowed to discontinue a few of our varieties."

THE BUSINESS OF A HIGHWAY COMMISSION

(Continued from page 114)

proportionately with the amount of road purchased, and the problems to be solved will also vary and depend upon the local condition and requirements.

This purchasing machinery can also be called the engineering organization, and it is the business of a highway commission to create and make up an engineering organization which should be able to assist the contractor in carrying out his work, in such a manner as to cause no unnecessary expense to the contractor, and at the same time, see that the contractor holds to his part of the agreement in delivering the road purchased. The engineers' department must see that all materials entering into the road surface meet with the requirements of the agreement. The inspection and testing of these materials must be carried on in such a manner as to cause no delays in construction, the testing being done preferably at the point of shipment. With the materials having passed the specification requirements, the next step is to see that these materials are incorporated into the road in such a way as to produce the best possible work. Only inspectors of the best training and long experience should be used for this work. For long periods, commissions have made the mistake of securing high-class talent in engineering, but when it comes to the actual inspection of incorporating the materials into the roadway, this work is too often inspected by a man of no experience; a condition which causes the contractor much expense and rarely ends in anything but a disadvantage to the state. Highway commissioners will find it a great saving to carry on short courses of instruction for field inspectors. Happily, indeed, universities and colleges have now recognized highway engineering, and more well-trained men for highway work are becoming available each year. Many instances could be cited of cases between low-grade inspectors and contractors, which would not only be interesting, but some of them sad and sorrowful, if consideration is given to the results.

Again, it is fortunate indeed that there are now with us only in tradition cases where highway commissions have not received from the old time contractor, their rightful purchase in roads. The purchase of roads has now been placed upon a higher business plane, honored and occupied by individuals and corporations.

In carrying out the purchase of roads on scientific basis, the commission must be represented in the fields where the road is constructed, and at the point of manufacture, where the materials are made. The highway commission, through its engineering department, should know in a general way, the condition of all State purchases, sources of all materials, and the character of the work being done by contractors. It is also necessary that a well-equipped laboratory is maintained for the purpose of assuring the highway commission that the materials equal to the specifications have been furnished.

While the highway commission's main purpose is the purchase of roads, which it designs and specifies, there remains also the necessity of carrying on at all times research work for the purpose of taking advantage of any new or recent discoveries in materials or methods, or adopting the most economic materials for the construction of improved roads. This research laboratory should also have for its work the responsibilities of a material survey, which provided the commission with information whereby the best and most economical material may be considered for the road improvement.

An example of the research laboratory is evident in the development of the improved subgrade highway. North Carolina now has a bond issue of fifty million dollars, provided for the purchase of roads. It is the business of the North Carolina State Highway Commission to purchase for the taxpayers of the State, road improvements which will serve the most people of the State and do the greatest economic good. It can readily be seen that most people can receive the greatest benefit by maintaining and bringing to a higher degree of usefulness the present roads, and so it was the business of the North Carolina Commission to first purchase and provide through its maintenance organization, highways, smooth and firm and capable of withstanding the traffic.

Following the same business principles which are manifested in the maintaining of a large mileage of highways, a large mileage of road may be constructed at a low cost by following the ordinary principles of grading and construction of drainage structures, and then building a subgrade of selected material. For some time, many of the southern States have been constructing the sand, clay and top soil highways, which, in reality, are subgrades which at some later period will be covered by a roadway of a higher type. The roads of this type have been found satisfactory for many seasons of the year, and this, in a degree, can be considered as economically solving the construction of a large road mileage at a moderate cost. Roads of this type are called progressive type roads. They are roads which have been graded in the ordinary manner, satisfactory drainage structures have been constructed and a subgrade of selected material has been built. This sand clay or top soil road or selected subgrade, can be maintained at a moderate cost, and with moderate traffic, is a satisfactory road for the greater period of the year. This is a progressive road because of the fact that its construction can be added to, and advantage taken of all the previous steps in construction.

This subgrade highway may be still further improved as has been demonstrated in one of the North Carolina experiments. This consists of a method of treatment of a "subgrade highway" which seems to indicate that this type of roadway can be treated at a moderate cost so as to withstand, with satisfactory maintenance, a traffic of much heavier character than this highway has previously been able to withstand. Anyone familiar with a top soil or sand clay road has undoubtedly wondered at the strength of these roads when properly drained and protected from moisture. The only wear on these roads

when properly constructed, seems to be in the surface. Up to the present time, bituminous treatments of these subgrades or earth roads have been far from satisfactory because of the fact that the light oils have not sufficient binding qualities and the heavier bituminous material forms a mat on the surface of the road on account of the dust which collects immediately underneath the bituminous material. This has been overcome in North Carolina to a great extent, by making this bituminous mat an integral part of the road surface. This has been accomplished by constructing into the earth roads, a single layer of stone which becomes an integral part of the earth road, and also affords for the bituminous material, a stone surface which will not dust up and allow the bituminous mat to peel from the surface. Upon this reinforced or armored subgrade highway can be constructed practically any hard surface type which may at some future time be required. In the meantime, a roadway of bituminous appearance is supplied, capable of carrying moderate traffic at a reasonable maintenance cost. It is very doubtful if this treatment of subgrade highway will be satisfactory in the northern States where there is excessive frost, but in each of these States there is a solution for every problem, and it is the highway commission's business to employ a research for the purpose of solving just such problems.

When a highway commision has completed the construction of the roads, it has really only partly commenced business, for the true work of a commission is the operating or maintaining of the roads in a manner capable of economically carrying on the industrial, commercial and social relations. It is the business of a highway commission to create a maintenance organization which can at all times keep the roads in their best condition at the lowest cost. It is the business of the commission to see that the maintenance organization is so made up that responsibilities are shared by individuals, and that the system is divided into sections whereby patrolmen may be responsible for the condition of certain sections of the road. It is the business of the commission to see that the most modern and efficient equipment is used, taking into consideration that various types of roads need different types of equipment to carry on the maintenance.

The business of a highway commission is surely not complete unless it can render to the public an accurate account of the expenditure of all moneys. The exact cost of the construction organization and the exact cost of the maintenance organization, its testing laboratory and research work. It must be able to show the actual cost of construction of all roads and must surely show the cost of maintenance per mile per year for every piece of State highway. There are many detail problems arising such as purchase of materials, equipment, etc., but each of these must be handled as would an individual or corporation.

And so it can be summed up that the business of a highway commission is to purchase for the taxpayers the construction of highways, and having made that purchase, it is their further business to see that these highways are at all times economically maintained in their highest degree of excellence, carrying on all details of both construction and maintenance upon the same business principles which are manifested by a corporation or an individual.

The Use of Local Mineral Aggregates in Bituminous Macadam Roads*

By W. A. WELCH†

The proper use of local mineral aggregate in bituminous road construction means great economy in these days of high transportation and labor costs.

It is possible to build good bituminous macadam road surfaces with practically any stone or coarse gravel found in the United States, provided this aggregate is free from loam, dust and silt when used.

The bituminous mixture is at best a wearing surface like the rails of a railroad and it must be thoroughly and properly supported by the subgrade or it will fail. The subgrade is the real road—it must be properly placed, thoroughly drained, well settled and compacted, and, on such a subgrade, a bituminous surface can be laid successfully with a mineral aggregate of comparatively low crushing strength, except on main trunk roads. It is, of course, very necessary to thoroughly bond this aggregate and keep it free from moisture, dirt and dust, for these are, in my opinion, the greatest enemies of proper bonding.

A railways engineer establishes the size and weight of his rails in accordance with the weight and speed of his traffic. On main trunk lines, these rails are made heavy enough to carry the heavy fast traffic, in spite of minor defects in the subgrade, but on the branch lines and feeders, these rails are lighter for economy's sake. Your main trunk lines should have wearing surfaces which will carry any traffic and any speed, without failure, in spite of minor defects in the subgrade, but such surfaces are not necessary on minor roads and it is not economy to build them.

The safe crushing strength of trap rock or basalt averages approximately 350 tons per square foot of the granites, 350 tons per square foot, of the lime-

*Paper presented at Nineteenth Annual Convention of the American Road Builders' Association.

†Chief Engineer, Palisades Interstate Park Commission, New York, N. Y.

stones and marbles, 300 tons per square foot, of good air cooled slag, 300 tons per square foot, of the sandstone, 215 tons per square foot and ordinary chalk, 15 tons to the square foot.

Practically all the stone in this country comes within these limits and all of it save the chalk and very soft sandstones will make good bituminous macadam road surfaces. Specifications must vary with the types. The softer aggregates must be used in larger sizes, greater care exercised with them to keep out the dust and the rolling must be governed by the type of aggregate. The harder stone can be thoroughly compacted by heavy rollers and still penetrated and thoroughly bonded by the asphalt or tar, but the softer stones, when used in penetration work, must not be rolled as hard or they will not allow the binder to properly fill the voids, and care must be taken to keep the aggregate even, as many quarries have seams or stratas of soft shaley stone, which, if put in with the better material, will cause trouble.

More care must be taken with the top course or seal coat when the softer aggregates are used to insure a thorough coating on the actual wearing surface.

There is little accurate data obtainable on this subject, few experimental sections of which surfaces have been laid and watched. Of all the failures of bituminous macadam surfaces, which have come to my notice, none have been due, in any way, to the character of the mineral aggregate. By far the greater number of these failures are due to bad subgrade and the others to poor workmanship, dirt and dust in the aggregate or poor bonding, due to improper rolling and penetration. Many of these failures are due to frost action in the subgrade, or improper drainage, which permits this frost to heave up the surface, or the gradual accumulation of moisture in poorly drained places in the subgrade, which destroys the support of the wearing surface through no fault of that surface.

Other failures were plainly due to improper mixing or penetration, from careless workmanship; others to the careless use of dirty aggregate, so full of loam, silt or dust that the binder was not able to reach the stone or the aggregate was badly graded. And, some other failures are entirely due to bad or improperly heated binder. One sheet asphalt failure was due to the use of glacial silt, ground as fine as cement, as the only aggregate.

I know of one piece of penetration surface in which three experimental sections were laid, each of about 500 ft. In these sections were used trap rock, or very hard basalt, limestone, just an average grade and sandstone of good character, while, on all the rest of the road, granite of good grade was used. This surface was laid in three layers of 2, 2 and 1 in. Two years after opening, a seal coat was put on and nothing has been done with it in the past six years. The same materials were used on the seal coat and I can distinguish no difference at all in these four sections of pavement. This road has carried up to 400,000 cars and trucks per season of eight months and the pavement is in perfect condition; but, it is laid on a perfect subgrade and 18 in. of telford.

Between the entrance of a ferry slip and the foot of a mile-and-a-half long hill, brick paved, on concrete base, with grades from 5% to 8%, there is a rock fill 300 ft. long. As this fill was expected to settle, it was decided to lay a temporary cinder surface on it. Three inches of clean steam cinders were spread and rolled with a ten thousand pound roller and one gallon per yard of bituminous binder was applied and lightly covered with more cinders. Two years later, another application of ½ gallon per yard of binder was made and lightly covered with cinders; at the end of another two years, this 300 ft. of temporary surface is in perfect condition and more than 330,000 cars and trucks used it during the last eight months, and yet the crushing strength of cinders is not great.

In eastern Ohio and Western Pennsylvania, much slag has been used and when treated about like limestone has made good surfaces. Many surfaces have been laid with crushed gravel, which is, of course, just like good crushed stone, if properly screened and washed before crushing. The usual specifications for this aggregate is 60% or more of material to have angular fragments.

But some surfaces have been laid with gravel without crushing and when this aggregate was clean, properly sized and bonded, these surfaces have been good. In Massachusetts and other New England states, this uncrushed gravel aggregate has been extensively used in the so-called "tar concrete pavements" with success when the workmanship was good, and many old gravel roads have been successfully surfaced with only gravel aggregate.

Good workmanship means more in bituminous macadam surfaces than mineral aggregate does.

It would seem much wiser for the engineer to carefully study all available local mineral aggregate and prepare his specifications to permit the greatest possible use of it in his surfaces, than to fall into the easier method of copying standard specifications and so compelling contractors to import these aggregates and so greatly increase costs.

Better put this extra money in your subgrade work for that is really your road.

ROAD AND BRIDGE WORK IN MANITOBA

The municipalities of Cartier and St. Francois Xavier, a few miles west of Winnipeg, Canada, have voted to build five bridges over the Assiniboine River, between the village of Headingly and the town of Portage la Prairie.

These bridges represent an expenditure of approximately $90,000. The Provincial Government of Manitoba, according to the provisions of the Good Roads Act, provides half of the amount required for the construction of the bridges.

The municipality of Cartier has also approved the

issuing of a certificate of indebtedness to the amount of $199,000 for the construction of roads through the the district, the Provincial Government contributing about $83,000 of this sum under the Good Roads Act.

ROAD WORK IN SOUTH CAROLINA

A proposal to spend $34,000,000 within six years and to complete within that time 4,000 mi. of the state system, more than 600 mi. of which would be hard surfaced and the remainder surfaced with sand-clay, top soil, or gravel, is to be urged before the present session of the Legislature of South Carolina. In order that this proposal should conform to the Federal aid acts the state highway officials recently held conferences with representatives of the Bureau of Public Roads of the United States Department of Agriculure.

If this greatly expanded program is carried out, the state will match all of the Federal aid money now available and any future appropriation that may become available. Funds will be raised by automobile licenses, by continuing the state-wide 2-mill property tax, a 1-ct. per gallon motor fuel tax, and a bond issue of $10,000,000.

MONTANA CONCENTRATES ON GRAVEL ROADS

Montana is not to be embarrassed by lack of funds for so-called permanent roads. The highway department does not look to the construction of many miles of costly pavement but does desire to secure the greatest possible mileage with the funds available of well located and well drained gravel roads built by local labor with local materials. Outlining the policy of the department in this respect, Chief Engineer Edy points out that the state is committed to a reasonable road program; that the area of the state, approximately 147,000 sq. mi., and the density of population, only four per square mile, do not warrant the construction of a great mileage of expensive pavement nor does the ordinary traffic demand it.

The department appreciates also that the agricultural interests of the state can be made to pay for the roads only in proportion to the amount they use them; the automobile interests must expect to bear the burden of the cost of the road-building program.

The roads constructed by the department have all been in line with this general policy. A good, serviceable, and easy riding gravel road has been developed and the bulk of the state's road construction has been on this. Where the traffic has made necessary a more durable pavement has been constructed.

Throughout the road construction every effort has been made to give employment to residents of the state. Counties have built and are building a part of the roads under the supervision of the highway department and have ordinarily employed their own taxpayers entirely. Winter gravelling has also been developed by the department which has enabled farmers to earn much needed funds during the winter months.

ROAD BUILDING HAS GROWN TO PROMINENT NATIONAL INDUSTRY

Road building is one of the nation's largest industries, according to statistics compiled by the Bureau of Public Roads, United States Department of Agriculture, and surpasses such great industries as the manufacture of steel and iron as well as the production, sale and repair of automobiles. In December, 1920, less than 600,000 men were employed in the steel and iron industry. It is estimated that last year something like 750,000 men were engaged in making, selling, and repairing automobiles. As compared with this an army of approximately 1,000,000 men labored last year throughout the road-construction season in building and repairing the country's highways.

Fifty million tons of stone and gravel will be required by the 28,000 mi. of Federal aid roads either completed or under construction in the United States at the end of the present fiscal year, according to the estimates of the Bureau of Public Roads. Some idea of the quantity is given by the fact that it is equal to a million carloads. If the material were piled in one place in the form of a cube, it would be approximately 1,000 ft. in each direction, or nearly twice as high as Washington Monument.

EFFECT OF MOISTURE ON CONCRETE

While the properties of concrete have been investigated for many years, attention has largely been given to considerations of strength alone. Aside from the action of direct load, deformations are produced in concrete by changes in temperature and in moisture content. With reference to temperature changes in reinforced concrete, it is well known that concrete has practically the same coefficient of expansion as steel, so that the two materials contract or expand together. Moisture content, on the other hand, has the undesirable property of affecting concrete alone. Concrete, like wood, clay, and some other materials expands when it absorbs moisture and contracts when it is dried. Steel has no such action.

Bulletin No. 126 of the Engineering Station of the University of Illinois, entitled "A Study of the Effect of Moisture Content upon the Expansion and Contraction of Plain and Reinforced Concrete," contains some of the results of experiments made by Torata Matsumoto, a graduate student in Theoretical and Applied Mechanics at the University of Illinois, in 1918. Owing to his years of experience as an engineer on harbor works on the Island of Formosa, he was particularly interested in the question of the durability of concrete exposed to sea air and to the conditions found in a tropical climate. It is felt, however, that the results obtained apply to our ordinary conditions and may have many practical applications.

Copies of this Bulletin No. 126 may be had without charge by addressing the Engineering Experiment Station, Urbana, Illinois.

MEETINGS

Calendar of Coming Meetings

Feb. 21-22—Kentucky Association of Highway Contractors—Annual meeting, Louisville, Ky. Secretary, D. R. Lyman, Louisville, Ky.

June 4-6—American Association of Engineers—Annual convention, Salt Lake City, Utah. Secretary, C. E. Drayer, 63 E. Adams St., Chicago, Ill.

June 26-July 1—American Society for Testing Materials—Twenty-fifth annual meeting, Atlantic City, N. J. Secretary, C. L. Warwick, Engineers' Club Bldg., Philadephia, Pa.

STATUS OF FEDERAL AID ROAD WORK COMPLETED BY STATES

Measuring the network of federal aid highways spread over the country during the past 5½ years, the Bureau of Public Roads, United States Department of Agriculture, places their total length, January 1 last, at 28,741.6 mi., and their cost at approximately $500,000,000. The figures represent 12,907 mi. of completed roads over which traffic is flowing today and 15,834 mi. of roads under construction and on that date estimated to be, as a whole, 70 per cent. complete.

In mileage of completed federal aid roads, Texas leads with a total of 1,116.4 mi. In addition, there were under construction in Texas on January 1, a total of 1,381.9 mi. of federal aid highways, whose estimated total cost was nearly $22,000,000. Minnesota ranked second, with 1,066.6 mi., in the amount of completed federal aid highways, the cost of the system being slightly over $10,000,000. Of that sum the Federal Government paid $3,878,663. In Minnesota there were under construction the first of the year 791.2 mi. of federal aid highways whose estimated cost was placed at $10,055,757. Other states with comparatively large mileages of completed federal aid highways on January 1 were:

Illinois, 722.9 mi. costing $24,608,958, of which $11,221,464 was paid by the Federal Government; Nebraska, [illegible].7 mi. costing $3,627,767, of which the Federal [illegible] paid $1,735,763; Wisconsin, 500.6 mi. costing [illegible]; Arkansas, 438.2 mi. costing $5,148,080; [illegible] costing $11,017,390; Iowa, 422.4 mi., [illegible] North Carolina, 419.1 mi. costing [illegible]7.1 mi. costing $6,472,552; and [illegible] costing $8,081,285.

[illegible] highway construction in some [illegible]dle western states where the [illegible] of high type and the cost cor[illegible]r mile were as follows:

[illegible] mi. costing $19,002,504; Ohio, 370.2 mi. costing $12,475,569; New Jersey, 78.3 mi. costing $3,442,224; Massachusetts, 120.5 mi. costing $4,391,036; and Maryland, 137.8 mi. costing $3,752,233.

Projects under construction and the degree of their completion January 1 in other states were as follows:

California, 382.9 mi., 55 per cent. complete; Georgia, 492.9 mi., 65 per cent. complete; Iowa, 998.7 mi., 86 per cent. complete; Kansas, 471.8 mi,. 69 per cent. complete; Louisiana, 354.5 mi., 82 per cent. complete; Minnesota, 791.2 mi., 65 per cent. complete; Mississippi, 464.3 mi., 64 per cent. complete; Missouri, 535.1 mi., 70 per cent. complete; Montana 412.8 mi., 77 per cent. complete; Nebraska, 914.1 mi., 94 per cent. complete; New Mexico, 551.9 mi., 54 per cent. complete; New York, 347.9 mi., 44 per cent. complete; North Carolina, 507 mi., 88 per cent. complete; North Dakota, 810.2 mi., 80 per cent. complete; Ohio, 298.2 mi., 91 per cent. complete; Oklahoma, 308.2 mi., 64 per cent. complete; Pennsylvania, 248.6 mi., 94 per cent. complete; South Carolina, 410.7 mi., 59 per cent. complete; South Dakota, 688.7 mi., 70 per cent. complete; Tennessee, 449.1 mi., 46 per cent. complete; Texas, 1,381.9 mi., 59 per cent. complete; and Wisconsin, 538.8 mi., 75 per cent. complete.

A State-owned Cement Plant in Arkansas was urged by the Arkansas Chater of the American Association of Engineers in a resolution adopted at its annual meeting on Jan. 28. In the discussion opinions were expressed to the effect that cement prices are too high and as a result road work in the state is being hampered.

PERSONAL MENTION

C. H. Henning, Jr., has been appointed division engineer of the Texas State Highway Department, with headquarters at Fort Worth.

Henry J. Cox has resigned as division manager ot the Texas State Highway Department.

Capt. J. D. Fauntleroy, formerly District Engineer of the U. S. Bureau of Public Roads, has been appointed State Highway Engineer of Texas at a salary of $9,000 a year.

Charles Costigan, formerly County Engineer of Summit County, Ohio, is now connected with the Metropolitan Construction Co., Columbus, O., Road Contractors.

F. M. Feiker, vice-president of the McGraw-Hill Publishing Company, who for the past eight months has been assisting Secretary of Commerce Hoover in the reorganization of the department, has resigned. Mr. Feiker, however, has been appointed a special agent of the department and will continue in a consulting capacity.

GOOD ROADS

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TABLE OF CONTENTS

*Roads and Trails in Alaska. By Col. James Gordon Steese 121

Standardized Specifications for Mineral Aggregates for Asphalt Pavements. By Roy M. Green . . 124

Inspection and Control of Concrete Aggregates. By R. W. Crum 127

Cooperation in Road Building. By William Ord . 131

$600,000,000 Spent on Roads in 1921 133

Relative Paving and Grading Costs on Federal Aid Projects 134

Earth Excavation and Unit Costs on 1,350 Federal Projects and Sections of Projects Completed . . 135

To Standardize Highway Bridge Design 136

Use Surplus War Canvas in Road Work . . . 136

Big Bond Issue Proposed for Kentucky 136

New Films Show Road Building 136

Will Study Skewed Bridges 136

EDITORIALS:

Proposed Bond Issue for Kentucky 129

Gasoline Taxes for Road Funds 129

Road Excavation Costs 129

Relative Grading and Paving Costs 129

MEETINGS:

Calendar 136

PERSONAL MENTION 136

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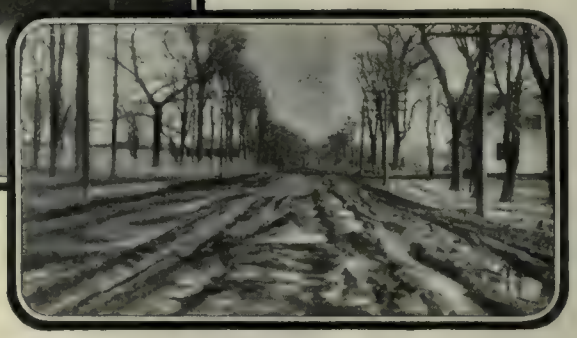

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Roads and Trails in Alaska

By COL. JAMES GORDON STEESE, M. AM. SOC. C. E.*

The provisions of the Federal Aid Road Acts are not applicable to the Territories of Alaska and Hawaii. In Alaska the construction, repair, and maintenance of roads, bridges, trails, and related works, is entrusted by law to the Alaska Road Commission. Prior to the organization of this commission in 1905, there were in the whole of the territory less than a dozen miles of what might be called wagon road, with a few hundred miles of pioneer trail, mostly constructed by expeditions under the War Department.

Travel was largely confined to the open waterways in summer and to their frozen courses or overland in winter. When mining machinery and other supplies were to be transported from the coast or river landings they were, in most cases, hauled over the snow during the winter, with some preliminary clearing of the route when necessary. Travel across country in summer, generally speaking, was possible only on foot or with pack horses. It was difficult always and frequently dangerous, on account of the numerous swift and deep streams, fed by the ice-cold and silt-laden waters of mountain glaciers.

The Alaska Road Commission is now composed of three officers of the Corps of Engineers of the Regular Army; in addition to the writer, Major John C. Gotwals is chief engineer, and Captain C. S. Ward, secretary-treasurer. Its funds are derived from an annual direct appropriation by Congress and from sixty-five per cent. of the "Alaska Fund," derived from vocational and trade license taxes, outside of incorporated towns. During its seventeen years of existence, it has expended about $7,000,000 upon a system of 6,290 mi. of roads and trails, reaching from open-all-the-year south coast ports to all inhabited parts of the territory.

This system consists at present of 1,101 mi. of wagon road, 756 mi. of sled road, 3,721 mi. of permanent trail, and 712 mi. of temporary flagged trail. In the classification of the commission, wagon roads are any roads cleared, grubbed, ditched, graded, and drained sufficiently to accommodate wagon traffic. Light motor vehicles are now using these roads in increasing numbers. This requires a gravel surface at an increased first cost, but with an eventual saving in annual maintenance charges. Sled roads are cleared and graded like wagon roads, but not grubbed. They are drained only sufficiently to prevent their destruction by the summer rains. Their wearing surface is of snow. Double bob-sleds, drawn by two, four, etc., horses haul heavy loads over these roads as well as over the wagon roads in winter time. During the past two seasons, caterpillar tractors were successfully used during the winter time, and such traffic is expected to in-

*President, Alaska Road Commission.

crease. Trails include any construction less than the above, suitable for dog sled or single horse-drawn, double-enders in winter and pack trains in summer. Except when river surfaces are used, some work is always necessary to permit the use of dog teams. Flagged trails represent cut-offs across frozen lakes, arms of the sea, etc. The marks are necessary to prevent travelers from getting lost in bad weather.

In addition to the funds of the Alaska Road Commission, there have been available since 1919 funds accruing to the Department of Agriculture for expenditure within or adjacent to the national forests. The Department of Agriculture has, therefore, been taking over projects of the Alaska Road Commission in these areas thereby releasing funds of the latter for expenditure in the interior of the territory. For the working season of 1919, the Alaska Road Commission supervised the work and built up an organization for the Department of Agriculture. Since July 1, 1920, that department has maintained a separate organization. About $600,000 have been expended from this source.

In 1919 the Territorial Legislature appropriated $400,000 for roads, for two years, and in 1921, $240,000. Of the first appropriation, about one-half was alloted to cooperative projects with the Alaska Road Commission, and the balance divided between cooperative projects with the Department of Agriculture and local projects handled by territorial agencies. Of the second appropriation, about $40,000 was alloted to cooperative projects with the Department of Agriculture and the balance is being expended under the supervision of the Alaska Road Commission.

The Territory of Alaska is more than twelve times the size of the State of New York or practically one-fifth the size of the United States proper. If it were superimposed upon the United States, the tip of southeastern eastern Alaska would touch Charleston, S. C., and the tip of the Aleutian Chain, Los Angeles, Cal.; north and south it would extend from Duluth, Minn., to Dallas, Tex. The coast line of Alaska aggregates 26,000 mi., or one-fourth greater than the entire continental United States. Due to its peculiar shape and to the difficulties and uncertainties of transportation, it would require over two years of continuous traveling by the best means of transportation procurable for a single individual to inspect the entire system of roads and trails for the maintenance and repair of which the Alaska Road Commission is responsible.

In addition to road and trail building for the Federal Government and for the territory, the members of the Alaska Road Commission are charged with river and harbor improvements in the territory and inspections and permits for all structures upon its navigable water, including floating and fixed fish traps for the great Alaskan fishing industry. The president of the commission is also detailed for consultation or to superintend the construction of repair of lighthouses and other aids to navigation authorized by Congress in the Sixteenth Alaska Lighthouse District, under the Secretary of Commerce, and as the War Department representative upon the Inter-Departmental Alaska Council.

The total expenditures during the past fiscal year amounted to $666,789.08, of which $432,243.90 was for construction, and $234,545.18 for maintenance. Work was performed upon 5,020 mi. of the system. During the current fiscal year (ending June 30, 1922) expenditures for all activities of the commission will aggregate about $900,000. The Alaska Road Commission has never professed to build hard-surfaced roads, nor would any such construction be justified in view of the great extent of country to be covered with very meager resources. In many isolated localities, the erection of a cableway and cage across a glacial stream or the setting of stakes across the open tundra is a matter of life and death to the inhabitants.

Though the commission began operations in 1905, its early appropriations were quite limited. By 1913, however, sufficient work had been done to warrant consideration of a general program of road and trail development. After a general overhauling of the situation, a recommendation was submitted calling for an expenditure of $7,250,000 during the succeeding ten years so as to provide Alaska with a road and trail system such as immediate needs justified and sufficient to meet all reasonable demands until the territory should be sufficiently developed to take over the internal public works as a part of its own government. Congress accepted this program in principle in 1916 and made an appropriation of $500,000 for that year, followed by a similar amount in 1917. Then the War caused the program to be practically abandoned.

In 1920 the present commission took charge and was faced with the need of reconstruction and rehabilitating a large part of the old routes, with the requirement of a more substantial type of construction and a road so surfaced as to stand light truck traffic, with the necessity for a system of highway feeders to the government railroad, with the need of extensions and improvements to the system in all parts of the territory, and all this with a greatly increased cost of labor, materials, and supplies. In its first report it recommended an expenditure of ten million dollars during the next ten years, about two-thirds during the next five years and the remaining third on a decreasing scale during the second five years. Work is being conducted upon this program, though Congress has not yet increased its appropriations sufficiently to warrant the expectation that the program will be completed within the time limit proposed.

The most important project of the commission is the Valdez-Circle Military Road, or Richardson Highway, extending from Valdez, an open-all-the-year south coast port, to Circle, on the Upper Yukon River, a distance of 531 mi., or about the distance from Boston to Richmond, or from Vancouver to Banff. This road is now

passable for automobiles throughout except for 79 mi. between Chatanika and Miller House, on the portage between the Yukon and Tanana Rivers. Construction upon this section is actively under way. The 371 mi. between Valdez and Fairbanks was passable for dog teams in 1909, for a light horse-drawn wagon in 1911, and in 1913, the first automobile made the through, overland trip which involves crossing the coast or Chugach Range through Thompson Pass at an elevation of 2,750 ft., and the main Rocky Mountains, or Alaskan Range, through Isabelle Pass, at an elevation of 3,300 ft. From Willow Creek, 92 mi. north of Valdez, there is a 39 mi. cut-off to Chitina, at mile 130 north of Cordova on the Copper River and Northwestern Railroad.

YUKON SLED IN ALASKA—DRIVER IN PARKA

Of even more importance than the wagon roads to the economic life of the interior are the winter sled roads and trails over which all mail, express, and personnel are handled. Even heavy freight can be handled by bob-sled in the winter time more economically than by truck in the summer time. Twenty-five cents per pound is not an uncommon charge for handling provisions and miscellaneous supplies over unimproved trails, and a community considers itself lucky when the through rate from the railroad, or river landing, is reduced to less than 10 ct. Data collected by the commission indicate that transportation charges upon freight actually passing over its roads and trails have been reduced over $2,000,000 annually due to the improved facilities provided. It is doubtful, however, if anything like that amount of freight would have been transported without the roads, and the indirect loss which would have been occasioned by the restriction on output and development if the roads did not exist, cannot be estimated.

The Talkeetna-Cache Creek Project affords a striking example of this. For years the commission had maintained a crude pack trail into this district and the production in 1919 and 1920 was only about $140,000 in gold. In 1920, the commission expended $75,000 on a 42 mi. route to the government railroad, opening up the entire mileage for sled traffic, and is continuing its improvement to road standard. Last winter 500 tons went into the district by bob-sled at a saving of 3 cts. per lb. or $30,000 over the old rate. As a result, several hydraulic plants are being installed and a hydro-electric plant is being built to furnish power for a dredge. In the near future this district will be one of the biggest producers along the government railroad, as the ground has been prospected and proven for years.

From Ruby on the Yukon River, the commission has built and maintains a good road to Long, 30 mi. south, and a poor trail for an additional 30 mi. to Poorman. The freight rate from Ruby to Long is 4 ct. per lb., and from Long to Poorman 15 ct. or 19 ct. for the 60 mi. (6.33 per ton mi., or over 1 mill per ton ft.). Operators on the creeks around Poorman ship everything possible, bacon, beans, canned milk, etc., by parcel post, which the Postoffice Department handles for 12 ct. per lb. and then pays the local freighter 19 ct. About $200,000 would improve the 30 mi. from Long to Poorman to wagon standard, whereupon the rate would immediately drop to 5 ct. per lb., a reduction of 10 ct. per lb. Some 300 tons actually passed over the trail last season. At a reduction of 10 ct. per lb. the immediate annual saving to the shippers would be $60,000 or 30 per cent on the investment. Development would also be stimulated and much additional freight handled.

During the opening of new diggings in the Chisana region a few years ago, beans, coffee, sugar, hay, candles, bacon, grain, etc., were all sold at $1.50 per lb.

Last summer, the freight charges for transporting supplies from Dawson in the Klondyke to some operators about one hundred miles away in the American 40-mi. District were greater than the original cost of the supplies plus the freight from the United States to the Klondyke. (Dawson is 1,700 mi. from Seattle.)

I have seen supplies (provisions, pipe, lumber, etc.) carried on the backs of Indians from the beach up a slippery mountain trail to mining properties at the rate of $60 per ton mi. or over 1 ct. per ton ft. Numerous similar examples could be cited, and it is hoped that Congress can be made to see the eventual economy of increasing the federal investment in this great pioneer country.

At the annual convention of the American Road Builders' Association in Chicago last month, two of the resolutions passed relate to this work; the first recommends the extension of the Federal Aid Road Acts to the territory; and the second urges immediate consolidation of the federal road building activities in the territory under the Alaska Road Commission as recommended by the Inter-Department Alaska Board and by the Governor of Alaska.

Standardized Specifications for Mineral Aggregates for Asphalt Pavements*

By ROY M. GREEN†

Many of the other details involved in arriving at satisfactory standard specifications for the construction of the various types of asphalt pavements are much simpler of solution than that of drawing up a suitable standard for the requirements of the mineral aggregates which might be universally adopted. For example, the asphalt cements that have been successfully used for the various types of work have been classified and placed in suitable groups for description in specifications and their physical properties are carefully controlled by the producers. Since the physical and chemical properties of the asphalt cements that have been used successfully are known, and there are relatively few producers of such materials, it is much easier to arrive at a suitable specification for them than is the case with the mineral aggregates where there are just as many different classes of materials as there are deposits of rock and gravel and their properties can not be controlled further than to regulate the maximum size of the particles and the variation in sizes. Ralizing these facts, it is readily appreciated that the materials available for use for any type of pavement in the different sections of the country will vary through a wide range. Since it is always desirable to obtain the best material in each locality, if it can be done economically, it is impossible to draft a standard which will be suitable for all parts of the United States. For these reasons, I believe that the standardization of the specifications for the aggregate to be used in the various asphalt pavement mixtures should not be arbitrarily drawn.

A standard specification for aggregate is of no value except as a guide in drafting specifications for local conditions and as a means of pointing out to the average engineer those points which should be taken into consideration in the description of materials desired for a specific purpose. The adoption of a standard specifications, in its entirety, often shuts out some local material of considerable merit, and in some cases may entirely shut out a type of construction by placing unnecessarily rigid requirements on certain materials that are essential for that type. In other words, standards for the requirements of the physical properties of aggregates should be based upon the materials available in any locality and should be drawn so as to admit all aggregates that have proven successful in like construction in the past, and should be strict enough so that all materials that have proven inferior are excluded.

In the discussion of this subject it is, therefore, my intention to discuss the physical properties that are essential to the success of the various aggregates for use of the different types of construction. The definite limiting test requirements given in the following pages are not intended for universal application but are what I consider as good practice for the materials available for use in Nebraska and adjoining states.

Since the properties of the mineral aggregate which are essential to the success of a bituminous wearing surface mixture are dependent upon the type of mixture which is contemplated, it will first be necessary to designate the types which are to be discussed.

For the purposes of this paper, the asphalt paving mixtures will be divided into four classes, as follows:

1. Sheet asphalt wearing surface mixtures.
2. Asphaltic concrete, with the material passing the 10-mesh sieve predominating.
3. Asphaltic concrete, with substantial proportions both passing and retained on the 10-mesh sieve.
4. Asphaltic concrete, with a preponderance of material retained on the 10-mesh sieve.

Sheet Asphalt Wearing Surface Mixtures

The function of the aggregate in a sheet asphalt wearing surface mixture is simply to furnish a medium whereby a high percentage of bitumen may be carried and still produce a mixture with density sufficient to prevent the entrance of water, toughness and elasticity sufficient to prevent crack and and spalling of the surface, and rigidity sufficient to prevent rolling and waving.

Through a long experience with this type of mixture it has been learned that this sort of a combination can best be produced by means of a mixture of properly graded sand, with the addition of a suitable amount of Portland cement or stone dust. Any properly graded sand that is made up of particles of sufficient toughness will meet the requirements for sand for this type of construction provided it is clean and does not contain too much material passing the 200-mesh sieve. The Portland cement or limestone dust is simply added to fill the smallest voids in the aggregate combination, thus promoting stability, and to increase the toughness of the mixture through the fact that the asphalt cement is absorbed by this aggregate to a very large extent. Experience has also shown that very fine sand, in large amounts will not replace the Portland cement or limestone dust as a filler but is in fact undesirable. This point should be covered by the specifications.

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Since the finished product desired for this type of construction is known, it is not necessary to specify the grading of sand desired and subsequently repeat this in the specifications for the finished mixture as is so often the custom.

This being the case it is only necessary to specify that the sand shall be clean, hard, and durable, the grading being given in the formula for the finished mixture. The amount of material passing the 200 mesh sieve should be limited. The description of the sand could be, as follows in the specifications.

Sand for Wearing Surface Mixture

The sand for the wearing surface mixture shall consist of clean, hard, durable grains, free from clay, loam and other foreign matter. Not more than six per cent of the sand for the wearing surface mixture shall pass a 200-mesh sieve and it shall be so graded as to produce a wearing surface mixture as hereinafter specified under "Composition of Wearing Surface Mixture," when combined with the mineral filler and asphalt cement.

Since the mineral filler in the mixture adds to its toughness by assisting in retaining a larger proportion of bitumen, by absorption, it is essential that it be fine enough to act as a true filler. The description of the filler could be given in the specifications as follows.

Mineral Filler

The mineral filler shall consist of limestone dust or Portland cement, which when tested by means of laboratory screens shall meet the following requirements:

	Per Cent
Passing 40 mesh sieve	100
Passing 200 mesh sieve, not less than	75

If this type of specification is used for the mineral aggregate it then becomes necessary to give a complete formula for the desired finished product. The following is suggested as being suitable for this purpose.

The materials entering into the wearing surface mixture shall be combined in such proportions as to produce a mixture conforming to the following limits of composition, by weight.

	Per Cent
Bitumen	9.5 to 12
Aggregate.	
Passing 200 mesh sieve	10 to 16
Passing 100 mesh and retained on 200 mesh sieve	5 to 20
Passing 80 mesh and retained on 100 mesh sieve	5 to 20
Passing 40 mesh and retained on 80 mesh sieve	20 to 40
Passing 10 mesh and retained on 40 mesh sieve	15 to 45

The finished mixture shall have not less than 30 per cent of aggregate passing the eighty mesh sieve.

Although these specifications have been reduced to a very simple statement of requirements, it must be understood that the aggregate grading must be carefully controlled, within the limits given, by someone who is competent to supervise this type of construction.

Asphaltic Concrete, with the Material Passing the 10 Mesh Sieve Predominating

In this type of construction, which includes the Topeka mixture, a small amount of stone is introduced in the mixing of fine bituminous mortar. The purpose of this stone in the aggregate is simply to reduce the cost of construction by reducing the surface area to be coated by the asphalt cement, since it requires much less bitumen to thoroughly coat the stone which is replacing a like volume of fine aggregate. The stone, or larger aggregate, in this type of mixture, does not contribute to its stability in any way as each particle is completely surrounded with the fine bituminous mortar and the larger particles are never in contact with each other. The success of such a combination is then dependent upon the correct proportioning of the finer particles of aggregate the same as in the case of the sheet asphalt wearing surface mixture. For this reason it is just as essential to produce a properly graded material having the same physical properties as the material used for the fine aggregate in the sheet asphalt. The specifications for the sand to be used in this type of construction should, therefore, be the same as for sheet asphalt.

The large aggregate is exposed in the entire surface of the pavement over a relatively small area of the total and it is therefore not so essential that the particles be as tough and hard as for use in mixtures where a very large area is exposed in this way. It is also absolutely essential that the maximum size of these particles should not exceed ½-in. in diameter as they are entirely surrounded by a bituminous mortar and if the size is great there will be a much greater tendency for movement in the mixture, due to stress at their edges.

In drawing specifications for the aggregate entering into pavements of this class it is well to specify limits of toughness and resistance to abrasion as well as requirement for cleanliness and a limit to the maximum size. The properties of the local materials that have been successfully used should be kept in mind in order that those materials that have given satisfactory service may not be eliminated by requirements that may be too strict. If this type of mixture is contemplated the following specifications for the coarse aggregate are suggested.

The crushed stone shall be produced from rock having a French coefficient of wear of not less than 8, and a toughness of not less than 8 when tested in accordance with the methods described in the U. S. Department of Agriculture Bulletin 347, pages 4 and 11, respectively. The crushed stone shall be reasonably uniform in quality and free from soft or disintegrated particles and shall vary from ½-in. to the smallest particle retained on the finest mesh screen commonly used in stone-crushing plants.

The specifications for sand and mineral filler should be the same as for sheet asphalt wearing surface mixtures as they serve a like purpose in this type of construction and should therefore be identical.

When this type of specification is used to describe the aggregates it is then essential to give a complete

description of the formula for the completed mixture. A good specification, and one which is in very common use is as follows:

	Per Cent
Bitumen	7 to 11
Aggregate.	
Passing 200 mesh sieve	5 to 11
Passing 80 mesh and retained on 200 mesh sieve	10 to 25
Passing 40 mesh and retained on 80 mesh sieve	11 to 36
Passing 10 mesh and retained on 40 mesh sieve	7 to 25
Passing ¼ in. screen and retained on 10 mesh sieve	11 to 25
Passing ½ in. and retained on ¼ inch screen	5 to 10

Asphaltic Concrete, with Substantial Proportions Both Passing and Retained on the 10 Mesh Sieve

When properly designed this class of mixture produces a dense asphaltic concrete with a high percentage of well graded stone, the particles of which are in very intimate contact with each other. The function of the stone in this mixture is to add to the stability of the combination by interlocking, and to reduce the surface area to be coated with asphalt cement and thus reduce the cost of construction. In order to be satisfactory in this aggregate the stone must have sufficient toughness and hardness to resist the internal wear that may be set up in the mixture as well as withstand the shocks of traffic that come directly upon the surface of the pavement. For these reasons it is essential that the stone be harder and tougher than that used in the preceding class of asphaltic concrete.

The mortar surrounding the particles of large aggregate in this combination must be suitably designed and proportioned also, in order that it may protect the large aggregate by holding it securely in place and thus prevent internal wear. The mortar must also cushion the effects of traffic on the surface so that the shocks will not be great enough to completely crush the large aggregate. To accomplish this purpose the sand must be properly graded the same as in the two preceding classes of pavements. The following clause will cover these details.

The mineral aggregate shall consist of hard crushed stone or an approved mixture of hard crushel stone and gravel for the coarse aggregate. Not less than 90 per cent of the coarse aggregate shall pass a 1-in. screen. To the coarse aggregate shall be combined sand or a mixture of sand and fine stone screenings for the smaller sizes.

The large aggregate, or that portion of the mineral aggregate larger than ¼-in. in diameter shall be composed of stone or gravel, all of which has been produced from materials having a French coefficient of wear of not less than 10 when tested in accordance with the methods described in the U. S. Department of Agriculture Bulletin 347, page 4. All the crushed stone larger than ¼-in. in diameter shall be produced from materials having a toughness of not less than 10 when tested in accordance with the methods described on page 11 of the U. S. Department of Agriculture Bulletin 347.

The coarse aggregate shall be reasonably uniform in quality and free from soft or disintegrated particles or other objectionable matter occurring free or as a coating on the aggregate, and free from an excess of flat or elongated pieces.

When this type of specification is used it is necessary to also give the formula for the mixture desired. The following is suggested for this purpose.

The dense bituminous concrete wearing surface mixture, produced in the manner hereinbefore set forth, shall contain the following percentages, by weight of bitumen and aggregate, the sieves being used in the order named.

Bitumen	5 to 8
Aggregate.	
Passing 200 mesh sieve	4 to 10
Passing 80 mesh and retained on 200 mesh sieve	4 to 14
Passing 10 mesh and retained on 80 mesh sieve	18 to 30
Passing ½ in. screen and retained on 10 mesh sieve	24 to 35
Passing 1 in. and retained on ½ in. screen	20 to 38
Passing 1¼ in. and retained on 1-in. screen	0 to 10

The finished mixture shall have from 55 to 70 per cent of mineral aggregate retained on a 10 mesh sieve, and not less than 10 per cent passing an 80 mesh sieve.

When Mixture Is Used as Closed Binder in Sheet Asphalt Construction

When mixtures of this class are used as closed binder in sheet asphalt, construction and combination is made up of a mixture of fine and coarse aggregate with asphalt cement, without the use of the fine filler of Portland cement or stone dust. The function of the coarse and fine aggregates are the same as in the case where it is used as a wearing surface. The large aggregate, however, need not be nearly so tough and hard since the shocks of traffic never come directly upon it and there is no possibility that there will be internal wear as the combination is always protected by a layer of fine bituminous mortar to a depth as great as one or even two inches.

The requirement for the sand should be the same as for other types of construction although the stone may be much softer. A suitable specification describing the stone might be as follows:

The stone for the binder course shall be produced from tough and durable rock having a French coefficient of wear of not less than 6 when tested in accordance with the methods described in the U. S. Department of Agriculture Bulletin 347, page 4. It shall be reasonably uniform in quality and free from foreign substances. When tested by means of laboratory screens it shall meet the following requirements and be uniformly graded between the limits given.

Passing 1-in. screen, not less than	95 per cent
Passing ¼ in. screen, not more than	10 per cent

Asphaltic Concrete, with a Preponderance of Material Retained on the 10-Mesh Sieve

This type of mixture is made up of a commercial size of broken stone or of "one size stone" mixed with a bituminous cement. The mixture produced in this way

is not an absolutely dense solid and no attempt should be made to fill the voids with the asphalt cement. The stability of the mixture is almost entirely dependent upon the interlocking of the large aggregate and the wearing qualities of the surface are almost entirely dependent upon the hardness and toughness of this material. For this reason it is absolutely essential that this material be as tough as possible in order to withstand the shocks of traffic and resist the effects of internal wear which is inevitable when this type of mixture is used.

The limits of the properties of the mineral aggregate that should be specified are dependent upon the amount of traffic that must be carried by the surface. If it is absolutely known that the traffic is to be composed entirely of rubber tired vehicles and is very light it is safe to allow the use of much softer rock than if the amount and nature of the traffic is unknown or is known to be severe and to consist of a large proportion of iron tired vehicles. If a severe traffic is contemplated it is necessary that the aggregate should be better than for any other type of asphaltic concrete mixture in as much as the aggregate must be of such quality that is capable of carrying all the wear of traffic, including wear and abrasion of the surface.

A reasonable specification for this type of material is that recommended by the American Society for Municipal Improvements in 1917, which is as follows:

The broken stone shall be subjected to abrasion and toughness tests conducted by the engineer in accordance with methods adopted by the American Society for Testing Materials, August 15, 1908. The broken stone used for the construction of the wearing course shall show a loss on abrasion of not more than 3.5 per cent or a French coefficient of wear of not less than 11.5, and its toughness shall not be less than 13.0.

Mixture Used as Open Binder in Sheet Asphalt Construction

If this class of mixture is used as an open binder for sheet asphalt construction the requirements of the aggregate are the same as for the aggregate for closed binder, already described.

In closing I wish to again draw your attention to the fact that it is not good policy to recommend, for universal adoption, a specification for the mineral aggregate for asphalt pavements and place limiting tests requirements on these materials because of the fact that materials differ so widely in nature in different localities and it is always advisable to draw specifications for materials so as to allow the use of only the best materials available in any locality so long as competition is obtained and the interests of economy served. While the specifications quoted are not intended for universal adoption it should be noticed that the large aggregate should be of better quality for the cheaper types of construction than for the more expensive. The last form of asphaltic concrete requiring the best large aggregate while sheet asphalt binder and also "Topeka" may be constructed by the use of poorer grade of stone.

For successful results with any specifications it is also absolutely essential that the mineral aggregate grading be controlled within very narrow limits by one who understands the fundamental principles underlying the various asphalt paving mixtures and who is experienced in their construction.

Inspection and Control of Concrete Materials*

By R. W. CRUM†

The inspection and control of materials used in the construction of concrete roads are certainly factors of large importance in the success of such enormous undertakings at the present time. The importane of having an adequate organization to care for these factors can scarcely be controverted. That the inspection and control of the materials should both be the responsibility of a single department of a state highway administration is logical and is productive of good results. I do not believe that equally good results can be secured when the authority of the engineer in charge of tests stops when the material is accepted or rejected for use.

The making of concrete is a chemical process, and the quality of the concrete depends upon many factors outside of the influence of the mechanical processes involved. There will be no conflict in authority if the engineer in charge of materials carries the responsibility for the mechanical processes of manufacture. This division of responsibility may be compared so that in a cement mill, of which the plant chemist is held responsible for the quality of the product, and the superintendent for the production. The chemist chooses and combines his raw materials, exercising such authority in the plant as is necessary to insure the correct carrying out of his orders. The superintendent takes the materials at this point and completes the mechanical process of manufacture. In a like manner on a concrete road the engineer of materials should be responsible for the materials used and their combinations and should exercise such authority upon the road as may be necessary for the proper carrying out of his orders.

These principles have been recognized in the organization for the construction work of the Iowa Highway Commission. Each project is in direct charge of a resident engineer, who is directly under the district engineer. The district engineer reports in turn to

*Paper presented before Iowa Engineering Society.

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both the construction engineer and the engineer of materials, as well as other department heads concerning matters within their jurisdictions. The construction engineer, engineer of materials and tests, and general inspectors attached to both departments visits the projects as often as possible and give detailed instruction to the resident engineer and his force. The material itself, as respect to quality may be inspected either at the source or upon arrival depending upon individual project conditions. We try, however, to have all material passed upon before it reaches the job.

The primary function of our department of materials and tests are:

(1) To study the materials available within the state and develop proper engineering methods for their use in the various classes of construction. This involves a great deal more than the writing of arbitrary specifications based upon commonly accepted usages.

(2) To find and develop, if necessary, the logical materials for each project. This covers bridge work and gravel and macadam roads as well as paving.

(3) To inspect every consignment of material intended for use under state supervision, and make proper disposal of same.

(4) To supervise the use of these materials to make sure that the results anticipated are obtained.

(5) To conduct research work to aid in the design of roads, and for the solution of problems peculiar to our condition. The proper use of the most available supply involves considerable research work.

The distribution of materials suitable for concrete roads in the different parts of the United States shows a wide variety of conditions, and I am aware that in many states which are blessed with an adequate and well distributed supply of aggregates, our primary problem of making proper use of what we have, will not be of paramount interest. However, I do believe that steady advances will be made in the use of materials, and that there is a possibility of improvement in even the most favored localities.

Owing to transportation costs, together with large construction operations in the surrounding states, we realize that Iowa public works must be built with materials produced in Iowa. Not all of the material which must ultimately be used will conform to the commonly accepted standards. Nevertheless, in order to discharge the duties which have been given to us as engineers, we must find out how to properly use these materials to the very best advantage. We might, of course, shirk this duty for a time by insisting upon the use of commonly accepted standards no matter what the cost, but this procedure would be neither good business nos good engineering. To give a single incident illustrative of our efforts to properly meet these conditions, I would refer to the use of concrete mixtures containing higher percentages of sand than have commonly been considered possible. The need arises from the fact that all gravel deposits in Iowa contain more than fifty per cent sand. To carry on the enormous amount of public work contemplated, and waste one-half of our sand supply in the process, as would be required if we adhered to such usual ratios of 1:2:3½, etc., would, as I said before, be neither good business nor good engineering. Accordingly through research work accomplished in Iowa and elsewhere, the department has been able to recommend a series of more economical mixtures, which in two years of use have demonstrated the possibility of making suitable concrete in this way. I will not go into the proof of this statement here. We have it. Study of this particular problem will probably go on for many years. Another pressing problem is in the proper use of our vast quantities of soft limestone.

Certainly a primary duty of any material department is to study the material resources of the state in order that the most logical sources may be used on each project. Probably in view of the recent great increase in road construction, only a few states have material production facilities up to present day demands. In Iowa at least this is far from being the case. We, therefore, keep prospecting parties constantly in the field studying local conditions. Illustrative of accomplishment along this line, the following instances are cited.

During 1920 and 1921 new sources of concrete aggregate were investigated and later developed for 11 of the 30 paving contracts completed in 1920 and 1921. All of these projects have been successfully completed from these sources as originally recommended. Upon some of these contracts an actual money saving to the county can be shown. Upon the others the advantage lay in the accelerated progress of the work. Four of the gravel pits were actually found by the prospecting parties of the highway commission. The development of the others was only made possible through the cooperation of the highway commission. Three were developed by the counties, five by the paving contractors and three by outside interests.

The average price per mile for 52.93 mi. of concrete pavement, upon which an actual money saving can be estimated was $39,300, as compared with an average price of $42,000 per mile for 111.61 mi. let under the same market conditions and using commercial materials.

Detailed estimates of the saving in cost on these various projects substantiate the approximation given above. We are also pleased to state that the contractors have come to realize that we have accurate knowledge concerning the material situation and consult us very freely before each letting.

The actual inspection of the materials entering into a road is of course a fundamental and vital function, but it is also one, which if well organized and administered on a basis of absolutely fair dealing, can be easily put on a reasonably efficient basis. There are always

(Continued on page 130)

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

Founded January, 1892

E. L. POWERS
Editor

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Cable Address: Gudrodes, New York

Copy for advertisements must reach the New York office by noon on Tuesday of the week before date of issue if proofs are to be submitted.

Copy for classified and other advertisements where proofs are not required will be accepted until noon on Monday of the week of issue.

Articles by road builders are solicited. They should be short and, if possible, accompanied by photographs. Those accepted will be paid for at current rates.

Volume LXII. March 1, 1922 Number 9

PROPOSED BOND ISSUE FOR KENTUCKY

The Lower House of the Kentucky Legislature has passed a measure providing for a referendum vote on a proposed $50,000,000 road bond issue. If this bond issue is approved by the people Kentucky will be able to construct a state system of highways, like the many other states that have voted bond issues during the past few years.

Kentucky was one of the first states to recognize the importance of roads to the public welfare. In 1820 the General Assembly of that state appropriated money for road work and in 1830 the sum of $50,000 was provided for highway improvement. By 1837 a total of two and one-half million dollars had been expended on road work. At that time the state highway department had a force of thirteen members and the chief engineer received a salary of $5,000, a magnificent salary at that period and an amount greater than a number of state highway engineers receive even at this day. However, state road work was suspended during and after the Civil War until 1912, when the State Road Department was formed. But during that period many turnpike companies were chartered and several thousand miles of roads were built with private capital.

GASOLINE TAXES FOR ROAD FUNDS

Fifteen states now impose a tax on gasoline and six other states are considering gasoline tax bills, according to the National Automobile Chamber of Commerce. It is quite probable that within a few years practically all the states will impose a tax upon gasoline, since this form of taxation is one of the most equitable in that it is distributed in proportion to the use of highways by motor vehicles. If an automobile uses ten gallons of gasoline, and another automobile uses twenty gallons of gasoline in a day, it is logical that the second should pay a greater tax than the first.

EARTH EXCAVATION UNIT COSTS

During the past five years 24,526,415 cu. yd. of earth excavation was completed on federal aid contracts, according to a communication to GOOD ROADS from the U. S. Bureau of Public Roads, printed elsewhere in this issue. The unit cost per yard in New England and the Middle Atlantic States (New York, New Jersey and Pennsylvania) during the entire period was twice the unit cost of earth excavation prevailing in other states. However, excavation in these eastern states forms a smaller part of road work than it does in other states; hence there is less competition among contractors. Also, labor is usually higher in the East than in the West.

Comparing the unit costs of earth excavation for the year 1921 with the year 1917, we find that 1921 costs are not very much higher than those of 1917; in other words, excavation costs have been materially reduced. During the years 1919 and 1920 excavation costs, in common with other road costs, reached their highest point, but in 1921 they started on a downward path and now are on a level comparable with that of 1917.

RELATIVE GRADING AND PAVING COSTS

What part of the cost of a road goes into grading and structures that are more or less permanent, and what part goes into the paving, which may eventually wear out?

This question is answered fully by statistics compiled by the Bureau of Public Roads of the United States Department of Agriculture, printed elsewhere in this issue, on 1,350 completed Federal-aid roads, involving 7,500 mi. of road, at a total cost of $112,000,000. Of the total cost, 21 per cent went into grading, 14 per cent into structure, 62 per cent into paving, and 3 per cent for engineering. These are the average figures for the whole of the United States, but there is considerable variation in different sections.

In the Middle Atlantic States, where grading is not heavy and paving must be built for heavy traffic, the cost of the paving rises to 75 per cent and the grading and structures fall to 15 per cent and 9 per cent, respectively.

In the Mountain States the problem is very different, much of the work being new construction with heavy grading, and the highest type of surface is not necessary. In this group of states the cost of grading amounted to 33 per cent, structures, 20 per cent, and paving 42 per cent.

INSPECTION AND CONTROL OF CONCRETE MATERIALS

(Continued from page 128)

problems relating to methods of testing and test limits, to occupy the attention of the laboratory and inspection force, but their principal endeavor must be to make sure that only materials capable of producing sound concrete go into the work.

There are two general schemes for handling the inspection at the shipping origin and after arrival at the destination. Although we have used both plans, depending upon local conditions, we strongly incline to the first method even at slightly increased expense. Practically all of our difficulties the past season arose from the rejection of material after arrival at the work. The rejection of material in this way always causes a controversy, which frequently results in hard feelings on the part of party whose financial interests are involved. On the other hand rejection of consignments of material at the source seldom hurt anyone's feelings or pocket book. Our need for plant inspection arises from the facts that we are using material in very much larger lots and under more rigid inspection than has ever before been the case. I can understand that in Pennsylvania, where the producers have become thoroughly accustomed to the usages and requirements of highway work that the second scheme of inspection is working very successfully.

During 1921 the department inspected and tested the material entering into 165 mi. of pavement, 1,013 mi of tile drains, and 2,005 bridges and culverts on the Iowa primary road system. This has involved the detailed examination of approximately 3,635 cars of cement, 5,625 cars of sand, 8,819 cars of screened gravel and crushed stone, 5,040 cars of pit run gravel, 425 cars of paved brick, 80 cars of reinforcing steel and 1,798 cars of drain tile. Tests were made upon 24.335 samples of material.

The control of the materials should not end when inspected for quality, but must at least continue until they are in the mixer. Conditions in Iowa require the use of a variety of mixtures, and in the case of gravel aggregates, we have adopted specifications for proportions on a weight basis. Since, thus far all actual measurements are made by volume, it is necessary for the plant inspector to make frequent determinations of the weight per unit volume of the materials in order that the proper relation of materials to each other may be maintained. We have become impressed with the fact, thoroughly demonstrated by adequate test data, that under older methods our concretes have been sadly lacking in uniformity as respects particularly the relation between sand and coarse aggregates. Variations of 25 per cent on samples analyzed from day to day are the rule rather that the exception. We have therefore adopted the following measures of control, (a) more frequent checking of measuring devices, (b) statement of proportions by weight, (c) rigid insistance upon compliance of material with the screening tolerance allowed by the specifications and (d) arrangement of proportions to minimize the bad effects of variation in the mixture. In the last case the ratio of cement to total aggregate is made such on a given job. that variations in the ratio of sand to coarse aggregate will add to rather than decrease the strength of the concrete. A necessary adjunct to the proper control of the materials is information as to the results accomplished. We cover this need by making specimens every day upon all paving projects for crushing, transverse and wear tests of the actual concrete in the road. Accompanying these specimens is a sieve analysis of the aggregate made upon a sample secured from the road, by washing out the cement from a large sample of concrete from the same batch. Many thousand of the specimens are tested and studied in the winter time. Later on, after the road has been in use for some time, cores large enough for testing are cut at regular intervals and yield much useful corroborative information.

The inspection and control of materials as outlined in this paper cannot be carried on without new problems and new phases of old problems constantly presenting themselves. The solution of these problems must be attacked and in this attack are involved technical researches of considerable magnitude. A vital need, in these formative days of real road building, for any highway department, is provision for the research work demanded by local conditions. The highway engineers also owe it to the public and each other to participate in the solution of the broader problems of highway economies and construction.

The force of the materials department can be used very efficiently during the winter months upon research problems and material resource surveys. Problems under investigation at the present time are as follows: methods of testing cement, crushed stone and lubricating oil; effect of shale pebbles upon concrete; proper methods for use of fine river sand; relation of various material factors to cracking of concrete pavements, involving crushing, transverse, and tensile tests of many combinations of materials; service tests of paint; quality of concrete mixing water; comparative value of various Iowa material.

In administering our department of materials and tests as outlined herein, we think we have been of some service to the county officials, contractors and material producers, as well as the engineers in charge of the work. We pride ourselves somewhat upon the attempts we have made to use any logical source of material supply offered. We hope to be able to do our work in a practical common sense way, so that all materials that should be used will be used and so that all the materials that are used will produce a first class job.

The New Jersey House has passed a bill providing for a referendum vote next November on a $40,000,000 bond issue to complete the state system of highways.

Cooperation in Road Building*

By WILLIAM ORD†

When I had looked my subject squarely in the eye and realized how impossible it would be to point out, in a paper of reasonable length, many of the innumerable and elusive days in which paper profits might disappear, I was not unmindful of the married couple who drove forty miles to the polls. Returning from the election the husband timidly enquired for whom the wife voted. "Jones," she said, "and whom did you vote for?" "Brown," said he, "and I might as well have stayed at home."

In discussing this subject, I shall repeat some things I have already said in the same connection, believing that there are certain fundamental truths applying to this matter which are of such vital concern to highway constructors that they cannot be stated too often.

In the first place, and dismissing such extraordinary considerations as war and post-war conditions, it is safe to say that more losses have been encountered by highway constructors through careless estimating and failure to analyze and anticipate in their bids many factors to be encountered, than from all other causes.

Lucky Bidder Must Be "From Missouri"

If a contractor is to be successful, he must exercise in the preparation of his bid the same degree of diligence and intelligence that he is willing and expects to exercise in the prosecution of the work after the contract is awarded him. Every constructor who would be a successful bidder, in the final meaning of that term, must be "from Missouri." He must ascertain from careful study just what he is doing when he submits a bid and not rely upon somebody else's judgment.

In times past, there has often been a tendency among constructors to take engineer's estimates on work as final criteria of the costs of same and to submit bids below those estimates with the apparent conviction that the gentlemen computing said estimates possessed some occult powers of divination which made it impossible for bidders to lose money so long as their bids remained within hailing distance of those estimates. This will not do! Engineers have an almost universal tendency to underestimate costs, because they do not pay the bills for work and it is difficult for anyone who does not to take into account the many theoretically hidden items of expense which, in practice, discover themselves to the constructor.

Estimate Based on Contractors' Bid

Further than this, the estimator of one of the leading state highway departments of the country said to me some years ago, "In making estimates, I do not attempt to figure what I think the work should really cost, but what I think the contractors will bid. If I turned in estimates to my department based upon my own judgment of the costs involved the contractors would soon make my figures look foolish."

This statement is pregnant with suggestion as to where many paper profits of constructors have disappeared in the past. It is believed that one of the greatest steps taken in recent years with a view to eliminating the irresponsible constructor has been the refusal of some State highway departments to give out the engineer's estimate in advance of the letting of work.

In addition to the losses resulting from a too high regard for engineers' estimates, cases are not wanting where would-be constructors have been willing to leave the preparation of their bids to some material or bonding man who was instrumental in interesting them in their efforts to secure a particular contract. None of us who have worked for any considerable number of years in the highway industry have failed to be conscious of the annual crop of new concerns (with more enthusiasm than practical experience) who have oftentimes been brought into the field through the efforts of some vendor bent upon securing a portion of a client's business after he secured an award.

Vendors Back Inexperienced Contractors

In his experience in the highway construction business the writer has, more than once, seen a condition of affairs existing where concerns, practically without capital, experience or equipment, were furnished not only with certified checks but with a complete set of bidding figures as well by some interested vendor. It is almost superfluous to say that the paper profits figured for many constructors of this type were not long in winging their flight.

Much loss has also been experienced due to attempts of unqualified estimators to apply cost data gleaned from hand books and trade literature upon the subject. Such data is good for bidding purposes only insofar as one is qualified by study and analysis to properly interpret and apply them to new conditions. Unless one is so qualified, attempting to use such data is like fooling with the proverbial buzz-saw, and it is not surprising that many paper profits so arrived at have promptly disappeared.

Cases are not wanting where bidders have submitted prices merely made to beat the previous low bidders. evidently and alone in the child-like faith that the previous low bidders could have made no mistake. Bids have also been submitted which were nothing more than an average of the bids submitted upon a number of other projects, all of which might have been entirely dissimilar from the projects for which the average was used. Such practices as the last two men-

*Paper presented at Nineteenth Annual Convention of the American Road Builders' Association.

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tioned are only comparable to trying to raise oneself by the boot straps and they have met with about the same measure of success.

Hasty Bids Court Losses

Even where constructors have possessed the necessary qualifications for careful analysis and estimating very considerable paper profits have disappeared through failure to give the subject the time necessary for the completion of a thoughtful bid.

Under existing State highway laws nearly all specifications require the contractor to assume many elements of risk and uncertainty which should properly be assumed by the States. So long as this condition of affairs exists, it is important that constructors cover these elements in their bids by a proper percentage of probable occurrence. Many paper profits have undoubtedly disappeared through failures to do this.

Add 15 Per Cent to Cover Risk

In a recent report of the Specifications Committee of a State Highway Constructors' Association, it was stated to be the belief of said committee that, in the State whose specifications were under discussion by them, at least 15 per cent. of the net estimated cost of a project should be added to cover elements of risk and uncertainty included in all contracts. The committee making this report consisted of five experienced highway constructors, three of whom were members of the American Society of Civil Engineers, one being a director of that Society and another the ex-chief engineer of a great State's highway department. It will therefore be seen that a majority of this committee had had practical experience with the working of highway specifications from both sides of the street. Their report deserves to be received with respect and careful consideration by constructors everywhere and the verdict rendered by them in the connection referred to, is another sermon on where "heap much" paper profits disappear.

The constructor who is saddled with an enormous plant investment on which he has earned little or no depreciation will say that in bidding he is faced, not with the question of what he ought to do in such matters, but with what he must do in order to secure further work and that, so long as he is in Rome, he must do as the Romans do and compete with other bidders who do not consider the above risks. This position upon the part of certain constructors reminds me of Dryden's satire upon the writers of the time of Charles II.

"The poets who must live by Courts or starve,
Were proud so good a government to serve,
Polluted the stage for some small snip of gain."
And seeking to serve their base and selfish ends,

Many highway constructors continue to "pollute" the best interests of themselves and their competitors by bidding prices which do not take proper account of the hardships so frequently resulting from the elements of risk and uncertainty included in most highway contracts. Highway departments and engineers have long recognized this tendency and apparent helplessness upon the part of constructors and some of them have not failed to take advantage of it to the limit.

Costs and Good Work Direct Variables

Like the law of action and reaction, construction costs and first class work are believed, in the final analysis, to be direct variables, in most cases, and well balanced. It is hard for highway departments to get something for nothing and it will, doubtless, generally be found, where risky bids have been accepted, that what is gained in first cost will ultimately be sacrificed either in speed or quality.

In further relation to the matter of risks included in conracts, the average constructor will say that if he undertook to add anything like 15 per cent to his estimated cost of work to cover the elements of risk and uncertainty, he would never get a job. The only answer to this question is that if constructors knowingly assume risks without under-writing them, they are not constructors at all in the real meaning of that term. Such concerns do not deserve to be classed as business ones but simply as gamblers and economic pariahs, as menaces to themselves, their fellow contractors and the public as well. Any insurance company or other well ordered business conducting its affairs upon such lines would soon end in bankruptcy and, given enough time, any construction concern following such practice will eventually come to grief. In order to be ultimately successful, constructors must conduct their estimating and operations upon well established business principles.

Business Principles Must Be Adopted

When highway constructors, as a class, come to a fuller realization of this principle, they will find that a considerable amount of the paper profits which often disappear due to friction with highway departments, prosecution of claims, and discouragement in the esprit de corps of their organizations will be saved to them. It is also believed that nothing like the elimination of these elements of risk and uncertainty in specifications (or else the proper covering of them in bids) will go so far toward building up the efficient and long lived highway construction organizations which will be found to be such a rarity at the present time when both qualifications referred to are considered.

When this has been accomplished, it is also believed that there will be fewer abandoned contracts and insolvent constructors, less loss, trouble and expense to the public in being deprived of the use of its highways through delayed and unsatisfactory work, a saving to the taxpayers in cheaper work resulting from the elimination of all risks possible and more efficient construction organizations and lower engineering costs to the States through more expeditious execution of work.

It will not be amiss to attempt to point out herein

some of the other considerations which are believed to be essential to the general factors involved and to the preparation of conservative bids upon the major items of work found upon practically all highway projects, failure to recognize any one of which may cause disappearance of paper profits.

General Contract Factors

(a) Failure to recognize the fact that, in normal times, a contract located close to large centers of population and production, cannot usually be prosecuted on as economical a wage scale as one comparatively removed from competition in this line.

(b) Use, in bidding, of lowest quotations on aggregates without careful examination into the character, suitability and possibilities for future rejection of the same as well as the producer's ability to furnish the maximum amount of material when and as required.

(c) Failure to play unloading and storage facilities so as to permit a producer of small capacity upon whom one may have to depend, to make shipments evenly at all times, or to enable stocking of material to cover strikes, embargoes and other contingencies.

(d) Failure to study available labor supply and prices likely to prevail for same during the life of a contract.

(e) Failure to study availability of cars and train movements involved with material shipments.

(f) Failure to consider whether one will be able to perform a prospective contract with an old and experienced organization or with a new organization to be assembled for the work in question.

Working Season Must Be Considered

(g) Failure to properly consider probable duration of working season and the expense incident to carrying an organization through the winter, particularly where this expense results from inability to complete project in one season as may be contemplated when submitting bid.

(h) Failure to recognize the fact that existing sidings for delivery of material may prove inadequate for proper prosecution of work and protection of progress and to include expense for construction of additional sidings or extension of existing facilities.

(i) Failure to consider suitability and volume of water supply and charge for additional equipment which may be necessitated through failure at any time of an anticipated source of supply.

(j) Failure to properly consider character of roads available for hauling and the resulting transportation costs under all weather conditions.

(k) Failure to investigate or consider, as far as practicable, character of engineers and inspectors to be dealt with.

(l) Failure to charge off the amount of plant depreciation which may be experienced from a falling market, unsatisfactory machinery purchased, or inability to complete work in anticipated time.

(m) Failure to properly analyze and consider soil, and topographic conditions, right of way problems, and any structural obstacles along right of way in their relation to wet weather, progress, transportation and resulting costs.

Sequence of Operations Important

(n) Failure to provide for proper and economical sequence of operations and for the most satisfactory and economical equipment for executing work in hand.

(o) Failure to charge on estimate for the cost of freight and handling on many small items of supplies, insignificant in themselves individually but amounting to a large sum in the aggregate.

(p) Failure to investigate cost of supplies such as lumber, coal, feed, etc., also leases, rentals, freight on plant, camps, warehouses, plant, traveling expenses, losses on transportation of labor, legal expenses and many other items which might be mentioned in their relation to a particular contract.

As an instance of what is meant by the last-named phrase, it will generally be found that on contracts with heavy excavation and masonry quantities (involving use of steam shovels, additional mixers, water lines and other accessories) then cost of items of supplies, repair parts, shop work, etc., will considerably exceed, both in amount and in percentage of labor, what would be incurred where excavation and masonry quantities are light. Likewise, the expense for tools will vary greatly according to the number of outfits you will be required to use as well as according to the personnel and efficiency of your organization. It is not amiss to point out here that the expense for repair parts and shop work will increase considerably and directly in proportion to the age of your equipment.

Efficiency of and Organization Important

(q) Failure to recognize that costs used in compiling a bid may have been achieved under the direction of a more competent superintendent and a more efficient organization than you will be able to secure for the prospective project.

(r) Failure to properly consider the existing conditions and probable course of the markets during the life of a contract. This factor must always be balanced against cost figures procured from a contract already executed.

(Continued in next issue)

$600,000,000 SPENT ON ROADS IN 1921

The Bureau of Public Roads of the United States Department of Agriculture estimate the total expenditure for construction and maintenance of roads in the country in 1921 to be $600,000,000. The sources of this fund are approximately as follows: Motor-vehicle revenue, 19 per cent; state road bonds, 7 per cent; local road bonds, 33 per cent; state taxes and appropriations, 12 per cent; federal aid, 14 per cent; county, township and district taxes and assessments, 14 per cent; and miscellaneous 1 per cent.

RELATIVE PAVING AND GRADING COSTS ON FEDERAL AID PROJECTS

(Compiled by U. S. Bureau of Public Roads)

Explanation of Items

TOTAL COST: All charges reported as construction cost.
FEDERAL AID: All payments made by the Federal Government.
GRADING: All charges for clearing, grubbing, excavation, etc.
ENGINEERING: Expense of engineering supervision during construction. Full costs not always reported by State Highway Departments.
PAVING: Cost of pavement in place.
SHOULDERS: Cost of shoulder material where segregated from paving costs.
STRUCTURES: Bridges, culverts, drainpipe, guard rail, retaining walls, etc

GEOGRAPHIC DIVISIONS STATES	Number of Projects and Sections	Total Cost	Federal Aid Paid	Miles	SUBDIVISION OF TOTAL COST									
					Grading	%	Paving	%	Shoulders	%	Structures	%	Engineering	%
TOTAL FOR ALL STATES	1,380	$ 112,325,302.11	$ 48,584,220.35	7,480.1	$ 24,122,204.73	21	$ 68,306,966.41	61	$ 869,461.47	1	$ 15,927,290.10	14	$ 3,177,329.39	3
NEW ENGLAND TOTAL	124	4,541,939.76	2,094,123.19	210.8	877,696.41	19	3,071,728.26	67	33,152.43	1	463,689.70	10	115,692.96	3
Maine	4	680,117.95	306,054.34	28.0	166,842.89	27	363,705.10	59	28,166.18	4	48,637.68	7	17,766.10	3
New Hampshire	96	1,616,772.98	776,002.43	104.5	303,644.64	19	1,014,080.82	62	[illegible]	0	256,298.64	[illegible]	41,095.82	3
Vermont	9	244,443.67	118,669.91	11.0	63,372.10	26	128,470.89	52	3,203.00	1	38,277.95	16	11,119.73	5
Massachusetts	15	1,014,245.63	448,716.11	37.7	156,271.82	15	787,981.84	78	---	0	50,163.47	5	19,828.70	2
Rhode Island	9	941,496.60	991,680.40	24.0	176,874.72	19	668,703.67	70	---	0	71,043.00	8	25,077.31	3
Connecticut	1	128,660.79	83,000.00	5.3	10,790.24	9	108,786.04	87	1,630.25	1	4,248.96	3	205.30	0
MIDDLE ATLANTIC TOTAL	49	6,765,174.38	2,909,177.68	179.9	1,039,066.64	15	4,910,241.26	73	127,934.18	2	626,198.96	9	69,733.35	1
New York	6	287,696.69	133,673.37	10.3	44,931.00	17	194,616.48	73	---	0	13,664.12	[illegible]	14,182.08	5
New Jersey	17	2,327,860.22	868,117.31	[illegible]	256,195.61	11	1,677,696.71	72	117,209.68	5	231,206.95	10	45,551.27	2
Pennsylvania	26	4,167,718.48	1,910,387.00	113.7	737,940.03	18	3,037,926.06	73	10,724.50	0	381,127.89	9	---	0
EAST NORTH CENTRAL TOTAL	416	19,469,297.69	8,325,853.27	[illegible]	2,682,649.16	14	14,824,525.68	76	227,695.28	1	1,583,796.73	8	150,630.84	1
Ohio	31	4,186,449.32	1,405,845.85	146.1	309,199.88	7	3,583,195.65	85	30,611.04	1	196,230.25	5	67,233.00	2
Indiana	11	1,729,241.66	839,537.85	43.6	176,339.38	10	1,365,840.41	79	147.36	0	154,176.96	9	32,757.55	2
Illinois	65	7,904,700.02	3,935,707.25	[illegible]	956,177.02	[illegible]	6,117,312.59	77	193,259.71	3	635,870.01	[illegible]	80.69	0
Michigan	26	1,948,787.60	899,825.52	111.0	347,077.03	[illegible]	1,415,622.64	73	155.95	0	184,463.26	9	1,418.72	0
Wisconsin	86	3,700,129.09	1,248,139.10	306.7	891,856.36	24	2,342,554.39	63	3,521.22	1	413,056.25	11	49,140.88	1
WEST NORTH CENTRAL TOTAL	148	13,240,102.24	6,667,204.25	1,421.9	3,801,967.93	25	9,744,334.83	64	20,496.60	0	1,381,907.68	9	319,395.20	2
Minnesota	73	7,552,239.13	2,906,506.78	679.5	2,540,567.49	31	4,249,958.26	56	11,907.70	[illegible]	804,599.99	11	145,205.69	2
Iowa	17	3,690,704.48	1,266,848.91	195.0	677,893.99	19	2,865,183.88	77	---	0	104,688.52	3	51,238.09	1
Missouri	14	867,484.06	357,276.79	78.5	116,751.75	[illegible]	609,005.28	71	5,958.20	[illegible]	99,176.12	11	36,612.71	4
North Dakota	11	342,572.40	156,725.68	[illegible]	192,322.11	56	21,095.88	6	---	0	110,213.50	32	18,940.91	6
South Dakota	5	254,576.72	122,813.20	22.5	36,506.04	14	143,427.37	56	---	0	67,827.27	27	6,814.04	3
Nebraska	18	539,428.44	194,435.61	[illegible]	150,094.54	28	336,876.42	62	---	0	35,109.18	[illegible]	17,348.30	3
Kansas	17	2,013,097.01	660,897.04	85.5	288,150.01	14	1,518,787.74	76	2,630.70	0	160,293.10	[illegible]	43,235.46	2
SOUTH ATLANTIC TOTAL	242	20,619,636.30	9,114,256.90	1,231.9	3,948,069.64	[illegible]	11,196,888.80	54	292,137.36	2	4,892,570.22	22	[illegible]	3
Delaware	6	1,615,761.46	393,654.63	28.1	306,825.92	19	1,177,823.01	73	---	0	113,414.53	7	16,700.00	1
Maryland	48	3,361,059.76	1,643,888.55	[illegible]	462,652.93	14	2,465,783.51	73	242,704.37	[illegible]	146,697.85	[illegible]	43,221.10	1
Virginia	27	1,235,083.90	604,166.41	100.3	344,361.90	28	723,275.51	58	---	[illegible]	122,982.27	11	34,394.22	3
West Virginia	18	610,782.71	281,101.72	31.5	99,014.65	[illegible]	463,560.42	76	2,062.00	[illegible]	41,301.76	7	4,843.88	1
North Carolina	42	2,954,675.61	1,285,578.54	[illegible]	680,949.66	23	1,777,718.97	[illegible]	5,303.88	[illegible]	386,892.55	[illegible]	103,810.55	4
South Carolina	43	2,421,883.86	1,135,761.47	247.3	747,880.13	31	1,077,824.63	45	10,678.25	[illegible]	494,109.45	20	91,391.40	4
Georgia	97	8,366,469.12	3,753,169.36	447.3	1,296,159.27	15	8,497,992.83	[illegible]	31,388.86	[illegible]	3,270,796.69	[illegible]	290,151.47	4
Florida	1	33,961.88	16,936.10	10.4	11,217.18	[illegible]	14,889.92	[illegible]	---	[illegible]	6,375.12	19	1,469.66	4
EAST SOUTH CENTRAL TOTAL	80	5,006,941.44	2,358,225.91	486.5	1,273,409.11	[illegible]	2,523,703.88	50	395.15	0	1,000,189.69	[illegible]	211,243.82	4
Kentucky	8	798,522.26	367,631.26	32.1	132,948.05	17	514,692.39	64	395.15	0	129,830.69	16	20,655.97	3
Tennessee	1	37,349.89	18,674.94	0.0	---	[illegible]	---	0	---	0	35,529.64	[illegible]	1,820.25	5
Alabama	47	2,859,245.30	1,342,151.90	268.5	764,367.57	27	1,326,173.31	46	---	0	626,866.09	22	141,838.33	5
Mississippi	24	1,313,824.21	629,767.79	185.9	376,093.49	[illegible]	682,838.18	52	---	0	207,963.27	16	46,929.27	3
WEST SOUTH CENTRAL TOTAL	142	12,681,089.91	5,030,667.87	1,230.3	1,429,774.02	11	8,756,203.47	68	102,503.61	1	2,180,399.37	17	380,179.44	3
Arkansas	34	4,169,887.97	1,291,367.10	359.7	98,149.18	2	3,823,420.86	92	1,105.56	0	120,227.12	3	126,985.25	3
Louisiana	18	1,198,009.29	613,939.71	130.6	153,470.64	[illegible]	803,391.25	[illegible]	73,825.03	5	126,084.91	10	41,237.46	3
Oklahoma	14	1,266,093.55	619,719.39	40.1	139,718.12	11	683,600.36	[illegible]	3,453.89	0	415,345.67	33	51,975.31	4
Texas	76	6,219,069.10	2,605,651.67	691.9	1,038,436.08	17	3,477,791.00	56	24,119.13	0	1,518,741.47	[illegible]	159,981.42	3
MOUNTAIN TOTAL	154	14,401,912.71	6,893,442.89	1,157.2	4,872,657.14	33	6,019,536.61	41	62,346.30	1	2,876,510.63	20	768,863.03	5
Montana	34	2,032,001.27	979,846.09	196.4	800,420.12	[illegible]	719,638.31	35	---	0	407,825.05	[illegible]	104,117.79	5
Idaho	23	3,448,448.01	1,894,986.66	216.1	1,733,232.24	[illegible]	1,029,882.75	30	27,838.64	1	478,583.88	14	178,940.50	5
Wyoming	[illegible]	2,295,347.16	1,067,122.09	296.0	716,066.19	[illegible]	787,852.43	[illegible]	293.15	0	694,381.77	30	126,753.62	6
Colorado	49	3,870,273.56	1,218,636.76	179.7	646,499.01	25	1,396,553.75	54	34,075.41	[illegible]	529,027.87	13	164,117.34	9
New Mexico	12	1,174,951.17	585,850.90	114.8	242,471.34	21	677,876.48	58	---	0	204 117.17	17	50,487.18	4
Arizona	21	2,172,569.39	1,048,405.88	88.3	407,025.51	19	1,062,002.32	50	---	0	604,378.02	28	79,143.54	3
Utah	2	34,700.60	16,330.84	0.4	1,501.28	[illegible]	13,866.24	40	---	0	18,160.29	52	1,372.82	4
Nevada	10	873,621.53	385,663.67	[illegible]	325,441.46	37	342,064.33	40	138.90	0	142,046.54	16	63,930.24	7
PACIFIC TOTAL	105	13,191,232.46	6,173,076.33	702.0	4,196,924.66	32	7,197,004.63	54	22,800.56	0	1,220,047.12	9	583,658.47	5
Washington	65	6,854,875.52	3,269,902.64	311.2	2,016,302.11	30	3,845,201.26	56	118.85	0	718,159.15	10	275,114.13	4
Oregon	28	4,213,454.95	1,960,346.72	[illegible]	1,493,844.54	35	2,177,414.58	52	22,681.85	1	307,279.20	7	212,296.78	5
California	14	2,112,884.99	972,725.97	121.6	686,758.03	32	1,135,188.77	54	79.86	0	194,608.77	9	96,249.56	5

EARTH EXCAVATION AND UNIT COSTS ON 1,350 FEDERAL AID PROJECTS AND SECTIONS OF PROJECTS COMPLETED

(Compiled by U. S. Bureau of Public Roads)

Year and Quarter Contracts Let	NEW ENGLAND: Maine Vermont New Hampshire Massachusetts Rhode Island Connecticut		MIDDLE ATLANTIC: New York New Jersey Pennsylvania		E.NORTH CENTRAL: Ohio Indiana Michigan Wisconsin Illinois		W.NORTH CENTRAL: Iowa Nebraska Kansas Minnesota Missouri North Dakota South Dakota		SOUTH ATLANTIC: Virginia Florida West Virginia North Carolina South Carolina Delaware Georgia Maryland		E.SOUTH CENTRAL: Tennessee Kentucky Alabama Mississippi		W.SOUTH CENTRAL: Oklahoma Texas Arkansas Louisiana		MOUNTAIN: Nevada Montana Utah Idaho Arizona Wyoming New Mexico Colorado		PACIFIC: California Oregon Washington		TOTALS FOR UNITED STATES	
	Cu. Yds.	Rate	Cu. Yds.	Rate	Cu. Yds.	Rate	Cu. Yds.	Rate	Cu. Yds.	Rate	Cu. Yds.	Rate	Cu. Yds.	Rate	Cu. Yds.	Rate	Cu. Yds.	Rate	Cu. Yds.	Rate
1917 1st Quarter	---	$---	---	$---	---	$---	---	$---	---	$---	---	$---	---	$---	---	---	12,671	0.49	12,671	0.49
2nd "	7,613	0.90	---	---	---	---	---	---	26,646	0.39	---	---	62,261	0.19	---	---	10,000	0.30	106,520	0.30
3d "	17,188	1.11	---	---	---	---	138,265	0.33	77,991	0.30	37,293	0.23	57,452	0.21	---	---	---	---	328,189	0.33
4th "	14,514	0.89	27,763	1.34	8,132	0.45	---	---	45,363	0.22	15,563	0.34	91,894	0.26	---	---	211,152	0.30	414,381	0.39
Total & average	39,315	0.99	27,763	1.34	8,132	0.45	138,265	0.33	150,000	0.29	52,856	0.26	211,607	0.23	---	---	233,823	0.31	861,761	0.352
1918 1st Quarter	---	---	29,753	1.10	35,812	0.50	2,898	0.30	8,600	0.35	45,877	0.25	---	---	---	---	---	---	122,940	0.53
2nd "	6,461	1.05	76,701	1.43	166,044	0.58	797,682	0.32	198,936	0.89	87,813	0.37	30,128	0.67	49,262	0.22	---	---	1,413,027	0.500
3d "	692	0.85	76,091	1.36	302,651	0.56	202,183	0.35	30,282	0.33	77,980	0.30	30,281	0.28	379,708	0.43	54,708	0.41	1,154,756	0.49
4th "	7,230	0.92	9,863	1.35	---	---	304,038	0.34	14,107	0.70	211,790	0.29	6,000	0.70	151,771	0.44	42,952	0.40	747,751	0.38
Total & Average	14,383	0.98	192,408	1.35	504,707	0.56	1,306,801	0.33	251,905	0.79	423,460	0.30	66,409	0.49	580,741	0.41	97,660	0.41	3,438,474	0.471
1919 1st Quarter	16,470	0.99	---	---	50,993	0.59	500,461	0.38	99,349	0.37	112,651	0.37	201,372	0.31	10,738	0.75	182,307	0.46	1,174,341	0.38
2nd "	58,846	1.30	256,650	1.33	1,154,467	0.72	1,965,105	0.44	408,076	0.74	266,767	0.50	96,710	0.37	375,567	0.54	333,051	0.52	4,915,239	0.60
3d "	76,867	1.24	7,315	1.26	745,144	0.72	1,014,310	0.49	440,643	0.65	256,304	0.51	124,919	0.28	606,674	0.48	1,165,081	0.59	4,439,257	0.58
4th "	19,402	1.19	---	---	34,272	0.89	128,630	0.52	684,982	0.65	127,192	0.44	106,698	0.44	231,614	0.56	696,200	0.82	2,028,990	0.67
Total & Average	171,585	1.23	263,965	1.32	1,984,876	0.72	3,608,506	0.44	1,633,050	0.66	762,914	0.45	529,699	0.34	1,226,593	0.52	2,376,639	0.63	12,557,827	0.583
1920 1st Quarter	---	---	---	---	86,676	0.88	412,965	0.85	344,457	0.65	367,126	0.46	166,975	0.52	357,163	0.64	82,053	0.79	1,817,415	0.64
2nd "	50,257	1.60	---	---	378,604	0.70	704,347	0.64	279,029	0.51	62,840	0.27	84,488	0.40	571,296	0.60	345,146	0.66	2,476,007	0.62
3d "	61,827	1.69	---	---	104,604	0.60	334,403	0.50	765,072	0.58	146,661	0.53	46,800	0.49	649,876	0.53	31,772	0.70	2,143,215	0.59
4th "	2,774	1.54	---	---	75,506	0.36	96,793	0.57	218,220	0.54	---	---	121,155	0.26	67,998	0.56	63,906	0.68	646,352	0.49
Total & Average	114,858	1.65	---	---	645,390	0.66	1,548,508	0.66	1,606,776	0.58	576,827	0.46	421,418	0.42	1,646,333	0.55	522,877	0.68	7,082,969	0.604
1921 1st Quarter	---	---	---	---	---	---	10,274	0.71	171,780	0.58	94,306	0.34	630	0.55	77,757	0.52	---	---	354,747	0.50
2nd "	2,412	1.70	---	---	7,202	0.45	124,775	0.37	---	---	4,643	0.28	51,343	0.23	---	---	---	---	190,375	0.35
3d "	---	---	---	---	---	---	---	---	26,900	0.25	---	---	---	---	13,342	0.53	---	---	40,242	0.34
4th "	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Total & Average	2,412	1.70	---	---	7,202	0.45	135,049	0.39	198,680	0.53	98,949	0.34	51,973	0.24	91,099	0.52	---	---	585,364	0.445
Grand Total and General Averages	342,553	1.33	484,136	1.33	3,150,307	0.68	6,737,129	0.49	3,840,413	0.61	1915,006	0.41	1,281,106	0.35	3,544,766	0.52	3,230,999	0.61	24,526,415	0.562

MEETINGS

Calendar of Coming Meetings

June 4-6—American Association of Engineers—Annual convention, Salt Lake City, Utah. Secretary, C. E. Drayer, 63 E. Adams St., Chicago, Ill.

June 26-July 1—American Society for Testing Materials—Twenty-fifth annual meeting, Atlantic City, N. J. Secretary, C. L. Warwick, Engineers' Club Bldg., Philadephia, Pa.

TO STANDARDIZE HIGHWAY BRIDGE DESIGN

Greater standardization of practice in the design and construction of highway bridges is urged by the Bureau of Public Roads. It is believed that there is no sound reason for the amount of variation in specifications that now exists and that it results in greater cost of bridges. State officials take the same view as the bureau and a committee composed of bridge engineers has been appointed by the American Association of State Highway Officials to consider the matter. A "Manual of Practice" is being prepared, which will represent the best thought on the subject and which it is believed will be accepted by all the state highway departments. Not only will the adoption of such a manual lead to the building of bridges of good design, but it will also make possible a saving in money, at bridge companies will not be called upon to meet so much variation in design.

USE SURPLUS WAR CANVAS IN ROAD WORK

Seven million square yards of canvas duck received by the Bureau of Public Roads, United States Department of Agriculture, as surplus war material, is now being distributed to state highway departments for use in roads construction. A great quantity of the material will be used to protect concrete roads from the sun while they are being cured and to protect from rain cement piled ready for use on the roads. It will also be used as tents for road construction gangs, roofs for temporary storage houses and garages, and to cover road machinery in bad weather.

BIG BOND ISSUE PROPOSED FOR KENTUCKY

The $50,000,000 state road bill has been passed by the Kentucky House by a vote of 63 to 34. It now goes to the Senate. The measure provides for submission to the voters at the November election a proposition to issue $50,000,000 worth of bands to be used within the next five years for building 4,000 miles of state highway system. It pledges the gasoline tax, the automobile license tax and the 3-cent road tax to pay the issue off in thirty years. A provision allowing a 5-cent property tax is included, its proponents say, to make the bonds salable.

NEW FILMS SHOW ROAD BUILDING

Close-ups of the activities of the Bureau of Public Roads are contained in two films recently released, "Building Bituminous Roads," and "Mixed Asphalt Pavements."

"Building Bituminous Roads" deals directly with the surface treated and penetration macadam type of bituminous roads.

"Mixed Asphalt Pavements" embraces the construction of asphaltic concrete and sheet asphalt roads, and carries the audience from the paving plant, where the materials are mixed, to the completed highway, open for traffic. Scenes depicting the actual construction of the various types of roads were made under the direction of skilled engineers of the Bureau of Public Roads, United States Department of Agriculture, and are designed to instruct the layman as well as the engineer in modern road-building practices. Several animated close-ups graphically depict the details of construction.

WILL STUDY SKEWED BRIDGES

Methods of calculating the stresses and proportioning the size of skewed concrete-arch bridges which have been considered good practice in the past may be incorrect and result in the collapse of the structure, according to engineers of the Bureau of Public Roads.

PERSONAL MENTION

Charles F. Lang has resigned as president of the Lakewood Engineering Co., Cleveland, O.

W. F. Cocke has resigned as assistant state highway engineer of Virginia to become state highway engineer of Florida.

W. F. Cooper has been appointed assistant state highway engineer of Louisiana.

James M. Fourmey has been appointed state highway engineer of Louisiana.

Charles F. Puff, Jr., has resigned as secretary of the Pennsylvania Associated Highway Contractors' Association.

John MacCutcheon has been appointed superintendent of bridges at Bridgeport, Conn.

Arthur St. Laurent has been appointed chief engineer of the Canadian Department of Public Works.

Herbert Talley has resigned as chief engineer of the Hercules Powder Co. and is now associated with the United States Powder Co.

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

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TABLE OF CONTENTS

Safety and Beauty as Factors in Road Design and Construction. By A. R. Hirst 137

Knight Law Held Unconstitutional 144

Alabama Passes $25,000,000 Bond Issue 144

South America Will Build Roads with Machinery Made in U. S. 144

The Construction and Maintenance of Low Cost Road Surfaces. By William N. Bosler 145

The Disappearance of Paper Profits. By Henry H. Wilson 147

*Central Plant Mixed Concrete Tested for Maximum Safe Haul 148

Maricopa County, Arizona, Receives Bids 149

Wisconsin Has Big Road Program 149

EDITORIALS:

Safety and Beauty in Road Design 143

Road Work in Maricopa County, Arizona . . . 143

Road Work in 1921 143

Low Cost Road Surfaces 143

MEETINGS:

Calendar 150

Iowa Road Conference 150

Standards Committee Elects Officers 150

PERSONAL MENTION 150

OBITUARY 150

*Illustrated Article

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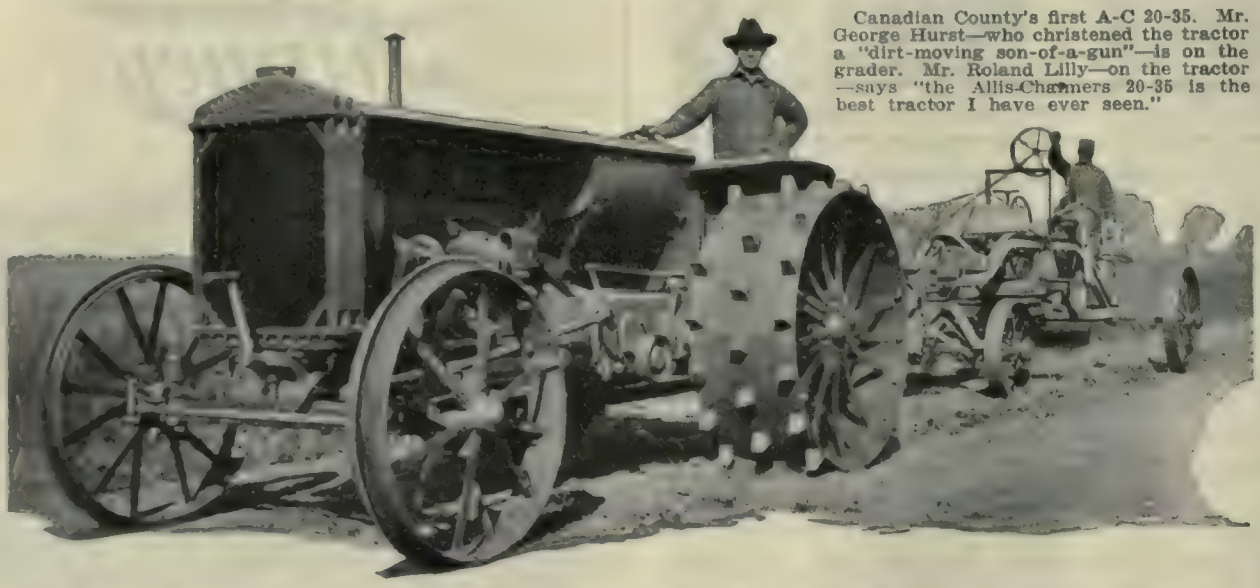


Canadian County's first A-C 20-35. Mr. George Hurst—who christened the tractor a "dirt-moving son-of-a-gun"—is on the grader. Mr. Roland Lilly—on the tractor—says "the Allis-Chalmers 20-35 is the best tractor I have ever seen."

Why Canadian County Bought Two More in 90 Days

OFFICIALS and road-builders of Canadian County, Oklahoma, are keen judges of tractors. For example, Mr. George Hurst—who operated the grader behind the first Allis-Chalmers tractor purchased by this county—has been building roads for years behind almost all makes of road-building tractors.

It was last September that Canadian County put its first Allis-Chalmers 20-35 to work in everything from river-sand to sun-baked gumbo. So powerful, economical and trouble-free was this tractor that within 90 days—as is shown by the letter reproduced here — Canadian County bought two more!

Canadian County's experience is only typical of that of counties, contractors and engineers who are turning to Allis-Chalmers power. They find the Allis-Chalmers 20-35 Special Road-Building Tractor best fitted for any of the many jobs of building and maintenance where dependability and speed is at a premium.

And there are reasons. For example, it is impossible to overheat the rugged, powerful Allis-Chalmers motor. Simple, close-coupled construction saves power for the drive wheels. All working parts are enclosed in dust-proof housings. "Frameless" construction means that nothing can get out of alignment. Drawbar swings so implement being drawn can be offset to the desired degree.

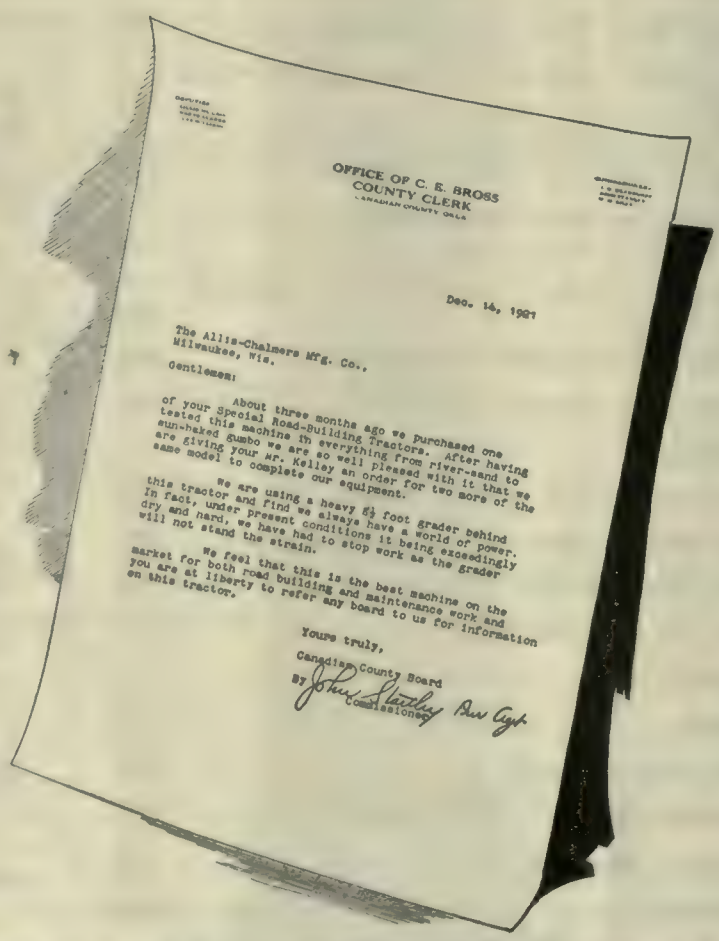
And finally, there are more drop-forged and pressed steel parts in Allis-Chalmers tractors than any others built.

Let us send you our new folder, "It's a Dirt Moving Son-of-a-Gun"

ALLIS-CHALMERS MFG. CO.
DEPT. E-2, MILWAUKEE, WIS.

ALLIS CHALMERS

20-35 Special Road-Building Tractor



OFFICE OF C. E. BROSS
COUNTY CLERK
CANADIAN COUNTY OKLA.

Dec. 14, 1921

The Allis-Chalmers Mfg. Co.,
Milwaukee, Wis.

Gentlemen:

About three months ago we purchased one of your Special Road-Building Tractors. After having tested this machine in everything from river-sand to sun-baked gumbo we are so well pleased with it that we are giving your Mr. Kelley an order for two more of the same model to complete our equipment.

We are using a heavy 8½ foot grader behind this tractor and find we always have a world of power. In fact, under present conditions it being exceedingly dry and hard, we have had to stop work as the grader will not stand the strain.

We feel that this is the best machine on the market for both road building and maintenance work and you are at liberty to refer any board to us for information on this tractor.

Yours truly,

Canadian County Board
By John Stanley
Commissioner Dist. Eight

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

WITH WHICH IS INCORPORATED

THE HIGHWAY CONTRACTOR AND ROAD BUILDER

Vol. LXII. NEW YORK, N. Y., MARCH 8, 1922 Number 10

Safety and Beauty as Factors in Road Design and Construction*

By A. R. HIRST†

Those highway officials who were concerned in the design and construction of highways prior to 1900 were fortunate in that they had to pay little attention to many factors which now very materially complicate the design of modern pavements. Then it was sufficient to grade well and drain a highway and place a macadam surface of narrow width, and about the only element of risk was the danger at unseparated railway crossings. Traffic was light, both in number and in weight, and slow moving. At that time a driving horse going at the rate of 20 mi. an hour was a meteor, and a heavily laden wagon an element of destruction unsurpassed.

In designing highways for present day traffic, the engineer is confronted with a much more intricate problem. Not only must he design highways which will withstand traffic, but he must also design them so as to be safe, and at the same time he must try to meet modern ideas of the aesthetic.

We are now designing and building highways, many of which have a traffic of over 10,000 vehicles on certain days, and many roads considered as of minor importance are carrying traffic of four or five hundred vehicles daily. This traffic moves very rapidly, the heavy as well as the lighter vehicles.

The vehicles used are driven in many cases by inexperienced persons, without proper poise, and sometimes by persons who are intoxicated. Never before in the history of the world were so many instrumentalities of destruction turned loose in the hands of persons so ill-fitted to direct them. We cannot design, construct or maintain highways upon the assumption that all drivers are going to use common sense.

Highways must be designed for the reckless, the thoughtless, and the intoxicated. If the consequences of the acts of these persons fell only upon themselves, we might disregard them as factors in the situation, because sooner or later they would efface themselves, and a short time more or less would not seem to be material. But they affect and concern the safety and lives of the much larger group which is using vehicles and highways with intelligence, care and judgment. These last must be protected, as far as possible, from the much smaller class which is a menace to all.

We probably cannot expect that methods of driving are going to improve or that we are going to reach within our time a period when driving is so regulated and checked that our highways are going to be used carefully and considerately by all. Rather do I imagine that matters will grow worse instead of better, unless our highway programs can proceed more rapidly than now seems possible. The few improved roads which we are able to secure are going to take greater and greater concentrations of traffic as time goes on. It is perhaps possible that some years from now the states may improve a sufficient number of roads so that many optional routes will be available and traffic thus be better distributed, but before that time comes we are going to have concentrations of traffic on certain routes which will be appalling in their magnitude.

Highways Must Be Safe As Well As Strong

For some years yet the rate of multiplication of motor vehicles is probably going to be greater in percentage than the rate of multiplication of adequate highways. The manufacturers of trucks and automobiles have by no means reached the limit of their achievements. We shall undoubtedly see automobiles radically cheaper, and motor trucks even more materially reduced in price. I am willing to risk the prediction that 15 years from now practically every American state will register double the number of motor vehicles that it registered in 1921.

Regardless of the growth of motor vehicle traffic in

*Paper presented at annual convention of the American Association of State Highway Officials.

†State Highway Engineer of Wisconsin.

the future, the amount which we now have is sufficient to make the safe design, construction, and maintenance of highways of the gravest importance.

In considering the design of a modern highway we should not forget that,—while naturally, we should so design a highway that the traffic can be carried by it,—just as important as the mere carrying capacity of the road and its ability to resist destruction is that it shall safely and expeditiously handle that traffic.

In other words, the building of a modern highway is the building of a transportation artery and in the design of it we should fully consider all transportation factors involved. The bare factor of getting traffic over the road so that it does not mire in the mud is a small part of the whole. Traffic should be enabled to move comfortabley, safely, and rapidly without danger either to itself or to other vehicles using the same roadbed.

We seldom stop to think that there are carried on many of our pricipal highways more passengers and more tonnage of freight per mile than on many important railroads. Railroads are not content merely to build tracks which will bear the weight of their trains. Railroads are so designed and constructed that trains can move expeditiously and safely, and every precaution is taken to prevent accidents. If it was good public policy to force the railroads to tremendous expenditures for the safety of railroad traffic, I can see no reason why it is not good public policy for the public to protect its own by building really safe highways.

Hazards Best Eliminated When System Is Laid Out

The first and best chance which a state highway department has of eliminating hazards in highway travel, is in the original layout of the highway system which it expects to build. In laying out the various highway systems toward which we are trending—that is, a Federal system, state systems, and county systems, it is possible by careful preliminary work and investigation in establishing the approximate future course of these highways to eliminate a considerable number of the present hazards, without expending anything but brain work in making the eliminations.

In many cases a little investigation of parallel roads will disclose a road potentially free from the objections which can be urged against the old road; in some cases grade crossings can be eliminated, or the number of right angle turns reduced, or better grades or alignment, or both, can be secured for the final road. It is my opinion that nothing can be more valuable in a territory in which modern highways have not yet been developed, than a careful consideration of every possible route with the idea of eliminating hazards before the road to be constructed is determined upon.

In laying out the Wisconsin state trunk highway system, it was possible for us to eliminate a large number of grade crossings with railroads, heavy grades, right angle and other dangerous curves, and other hazards without spending a dollar in construction but simply by selecting routes other than those which had been customarily followed. If we had this work to do over again we would be much more radical in making new routings.

Beauty Also a Factor to Consider

Another factor which should be considered in the layouts is that of making accessible or visible any feature of the landscape or topography which is extraordinary, beautiful or attractive. Weight given to the selection of routes which are attractive, scenically or artistically, will vary a great deal in accordance with the area traversed and the country served. Those states which are intending to capitalize and encourage tourist traffic should pay a very considerable amount of attention to the factor of having their roads run, wherever possible, where the scenery is attractive or where lakes, rivers, mountains, and forests, can be set out well and made fully accessible. In states or parts of states where these features are now present, there should be the strictest adherence to utilitarian practice in selecting the shortest road which will carry traffic safely and cheaply.

We have found, by sad experience, that any effort to serve two purposes with one road or to compromise on locations is a fatal mistake. Serve those purposes which should first be served with the right road, and if there is not enough mileage to go around, serve the other purposes with the right road later. As well try to make a good bird dog into a good rabbit dog as to try to combine routes in an effort to serve two or more divergent lines of traffic, to the lasting economic disadvantage of all traffic in the vicinity.

Some Fundamentals of Design for Safety

It is in the design of highway structures that the greatest advancement can be made towards securing both safety and beauty. Up to the present the principal idea of American highway engineers has been to build a structure which would stand up under traffic. Not only has very little attention been paid to the artistic, but in many cases very little attention has been paid to safety. Practice along safety lines is, however, making rapid advances as traffic becomes heavier and faster.

A great many accidents take place at curves, both vertical and horizontal, and it is at these critical points that the greatest advance in the art of highway design can be made. It has recently been stated that more accidents occur on straight highways than on curving and presumably dangerous highways. I doubt if this is true. If so, it is undoubtedly due to one or both of two causes (a) too narrow surfacing; (b) the presence of more traffic on the straightaway stretches than on the sections with excessive curvature.

I doubt not that in practically every case if the

exact number of vehicles and accidents were known, the road with the most sharp curves would show the most accidents per mile of traffic. A comparison of accidents without a comparison of traffic is worthless.

Vertical curves are almost as dangerous as horizontal curves, especially if the surfaces are narrow and the drivers do not keep to the right side of the road on approaching the crown of hills. Vertical curves should have a radius of at least 1,000 feet. With this radius an approaching vehicle can be seen 200 feet ahead, and there is comparative safety if there is moderately careful driving.

No horizontal curves of less than 300 ft. radius should be planned unless the circumstances are very exceptional on high speed main lines of travel, and on roads which carry the highest character of traffic almost any expenditure is justified in order to secure such curves or even easier ones. A curve of 300-ft. radius in cut gives vision only 200 ft. ahead and this is little enough when it is considered that two cars going 30 mi. an hour will meet in 2 sec. after seeing each other.

Super-Elevation and Widening Necessary

Curves should, of course, be super-elevated and widened. This practice is now general in the several states, and while in most cases it has not proceeded far enough, more radical super-elevtaions are being used each year. It is our opinion that on curves less than 300 ft. in radius, super-elevations up to 1 in. to the foot are desirable. All curves of less than 1,000-ft. radius should be widened, the widening being greater as the radius of the curve becomes smaller. If radii as small as 300 ft. are used, the widening should be to at least 24 ft. on a two-way road.

Where it is impossible to get curves with a radius of 300 ft. or more, if such a case exists, care should be taken to secure at least 200 ft. of vision ahead. Too many engineers are placing their curves so as to restrict the vision, when it is possible by throwing the ends of the tangents away from the bank to put in the same curve and still get vision past the bank. Cutting down banks to the line of vision is being practiced to some extent, but unless good maintenance is secured this is not proving as satisfactory as was expected.

Dead ends come under the same classification as curves. Dead ends are corners where the course of the main highway is not continued by an inferior highway, while the main highway makes a sharp turn. Treatment at such places should be just as radical as at curves, and added protection should be given by erecting white boarding across the dead end so that the driver is notified that the highway turns sharply. On such boards an arrow indicating the direction of the turn is helpful.

We wish to emphasize that the points of danger on our highways occur at curves, and on high speed, main lines of traffic too much money cannot be spent in securing good vision by building curves of easy radius. The fact that in every case an earlier curve shortens the center lines distance and thus reduces the amount of paving required, always helps to offset the additional cost of securing right of way for such curves.

Insufficient Width Also a Source of Danger

After curves, the factor which probably produces the greatest number of accidents is narrow surfacing. It is our opinion that no permanent roadway should be built of a width less than 18 ft. on any main line of travel, and that 20 ft. is a much better and safer width. We do not believe in building over 20 ft. wide unless a road for four lines of traffic is desired, in which case 36 ft. should be the minimum and 40 ft. would be much better.

It is the writer's opinion that pavements on high speed roads should be some multiple of 10 ft. wide, providing a lane 10 ft. wide for each line of traffic. Such widths as 14, 15, 16, 24 and 32 ft., and any other widths which do not provide a clear width of at least 9 ft. for each line of vehicles sought to be accommodated, are bastard widths and should never be used. Large amounts have been wasted, or partially wasted, in building pavements of such widths. If the traffic does not justify at least 18 ft., a 9 or 10-ft. road should be built so that no one will be deceived into believing that there is a double track road when none, in fact, exists. Such roads can be made double track roads later when funds become available. As stated in a previous paper, we believe also that wide pavements make for easier and cheaper maintenance, in that they keep the traffic off the edges of the pavement (which are always danger points), make for easier shoulder maintenance, and also provide for a moderate distribution of traffic.

Bridges and culverts should be built of adequate widths between endwalls. The distance between endwalls should at least equal to the width of the top of the fills when new. We suggest that on main lines of travel not less than 26 ft. should be used as the distance between endwalls or parapets of bridges and culverts, and if the grades are wider, greater distances should be provided.

In the design of bridges and culverts, especially in the endwalls and railings, there are great opportunities for the beautification of highways. Artistic paneling or spindles add very materially to the appearance of concrete structures without adding greatly to their cost. We also find that our people are willing to pay for the artistic once they have a sufficient number of samples of artistic bridges from which to judge the effects of good proportions and good design.

There is room for more artistic development in the construction of guard fences. Nothing, probably, adds more to the appearance of a highway than well constructed guard fence, well aligned and painted white as it should be. It is the concensus of opinion of our engineers that we, in common with most states, have

been using more guard fence than was necessary and that part of the money spent could well be saved and, if necessary, used in widening the fills. The use of paint or whitewash on stones to define the edge of fills, where the curvature or height of fill does not necessarily make the place dangerous, is recommended as both cheap and effective. There is so little horse-drawn traffic now that the old purpose of guard fence, to keep horses from jumping off the edges of fills when frightened by automobiles, is almost done away with.

Preserve the Trees

Every tree which adds any beauty to the landscape should be saved, if possible, and where there are groups of trees offering effective relief it is worth while to make changes in the center line to save these trees, even if additional right of way has to be secured on the other side. A good tree takes many years to grow and can be cut down in a few minutes. Most of us have been wasteful in our destruction of good trees and have not made the exceptions which should have been made in saving trees or groups of trees of distinctive character and merit.

Within the limits of slopes, brush and shrubbery, as well as all other vegetation, have to go. In many cases, however, the clearing and grubbing limits are defined as wider than the slope limits, and thousands of acres of effective shrubbery and flowers have been destroyed which could just as well have been saved. The clearing and grubbing limits should follow the slope line except in the northern states, where snow drifting can be expected. In such cases low-growing brush cannot be encouraged because it promotes snow drifting unless the line of brush is well back from the edge of cuts.

Incident to this point, we probably have not paid enough attention to buying additional right of way where snow drifts occur and planting shrubbery far enough back in the fields so that the snow will not be thrown into the road cuts. It is our opinion that this is the most effective method of keeping the roads open and should be used more generally. The debate between shrubbery and snow fences as means of locating snow drifts, is probably close, but we shall not enter into it here.

We have heard a good deal about tree planting along highways. We are entirely sympathetic with it if it is carried out and followed out by an organization which has some permanency, but the spasmodic trumpet blowing attempts to plant a few ineffective saplings on certain days and then think about them no more, have rather discouraged most of us who really believe in tree planting where the surounding circumstances permit. There have so far been more "nuts" bearing trees to plant than planted trees bearing nuts.

A good deal of this work has been done without forethought and judgment. If anything really effective is to be done it is the writer's opinion that it must be done by the state highway departments in cooperation with the state forestry departments, and not only just the trees stuck into the ground but they must be carefully attended until they become old enough to take care of themselves. We will undoubtedly see advances in this direction within the next few years. With good care and judgment exercised in the selection and planting of trees of suitable character there is nothing objectionable about planting trees along highways, and much to be said in favor of it. Even if in some cases a bonus has to be paid to abutting farmers on account of losses due to shading, it is well worth while from the public standpoint, and we believe it is possible to secure such relinquishment from abutting farmers where tree planting is advisable at a very reasonable cost, considering the artistic effects and real benefits to be secured. Even in well timbered states there are sections where a little green on the landscape and a little shade is very welcome, indeed.

The general remarks as to trees apply also to shrubbery. Planted with discretion shrubbery of the right kind of flowers certainly add very much to the general roadside appearance, and are worth money if the beautiful is ever worth money. All of these matters, however, will have to be developed slowly, because a very small fraction of our people are willing to spend any considerable amount of money in highway adornment. The highways are too badly needed, in the opinion of most people, to permit the spending of large funds in beautifying them. A good many feel that they cannot admire landscapes and artistic effects so long as the roads are impassable, and prefer to spend money in building the roads first and develop the beautiful later.

This objection can not be urged against saving what is already there, and much of this can be saved, not only without additional cost, but actually at less cost because of the lower expenditure for clearing and grubbing. We should not, however, allow beauty to interfere with safety. It is small solace to the injured or to the families of persons killed that accidents occur in and are due to beautiful surroundings. The smell of roses or honeysuckle is small solace in case of real disaster.

Eliminate Grade Crossings

After curves and narrow surfacing comes the next most prevalent cause of highway accidents—the railway grade crossings. The only safe grade crossing is one which has been eliminated. Many accidents testify that all forms of so-called crossing protection fall down, even flagmen and gates. In planning new main highways every possible effort should be made to secure the elimination of all grade crossings. Much can be done usually in relocating the highways so as to avoid crossing the railways at all. Where two crossings with the same railway line lie within five miles of each other, it will usually be cheaper to buy a new right of way on one side of the track and

grade and drain it than to separate the two crossings. If, however, there is something which must be met on the opposite side of the track, such as a village or city which it is necessary to accommodate, this course may not be feasible, although quite usually between the two crossings some point can be found where a separation can be made accommodating traffic to and from the city or village in question, while the main line of traffic is left free.

Each case must be decided upon its merits but both underground and overgrade crossings have disadvantages in alignment, and the best solution in four cases out of five, where the crossings are not too far apart, is to relocate along the side of the track. Where a highway must cross a railway an overhead is usually superior to an undergrade crossing for several reasons, and is usually less expensive.

Up to recent years about two out of three grade separations built by the railroads have, in reality, been more dangerous to highway traffic than the grade crossings they replaced, because the railroads paid no attention to the matter of highway alignment and in almost every case used crossings perpendicular to their tracks with two sharp and sometimes blind approach curves. Such crossings are seldom, if ever, satisfactory where the highway is in general paralleling the railroad as many main highways naturally do, and when skew crossings have to be built the decision almost inevitably falls upon relocating the highway.

Highway intersections, especially intersections of roads built for high speed are another source of grave danger. All intersections should be well signed on both highways and in addition good Y's should be put in in each direction, because such Y's serve to increase the vision for the traffic which crosses perpendicularly, and the traffic which makes the turn fits into line much better if its course is changed as it comes into its new line of travel.

At many crosings of two supremely important highways it is undoubtedly going to be necessary to separate the grades just as railroads have found it necessary to separate their important crossings. This may sound extreme, but where such cases exit on really important line of traffic, there can be no doubt that the separation of the two roadways is not only desirable but an economic necessity.

Safety Measures Used During Construction

Although the safety and the beauty of the highway depend principally upon the design, there are many accidents which are caused by failure to take proper precautions during construction. If a road is to be kept open to travel during construction, the safety and convenience of the traveling public should be the paramount consideration rather than a matter to be almost totally disregarded as is the case in too many instances at the present time.

Roads under construction should either be wholly closed to general traffic, or kept open under conditions which guarantee safe and easy passage. If kept open, grading should be kept closely in hand. On ordinary road work there is no great reason why there should be more than one mile between the completed grading and the first plowing ahead. Contractors would, in most cases, be much ahead if instead of spreading their work over the whole length of the contract and finishishing nothing until the last operation, they would keep the grading operation well in hand and finish as they go, starting a slope trimming and finishing crew as soon as the roughing out has proceeded not over a mile.

On many highway jobs the grade lifts are too heavy. Drops of 3 or 4 ft. at the end of a fill are not uncommon. This is contrary to most specifications, makes a poor road, poorly compacted, and besides gravely inconveniences the travel both in going up and down the breast. Even where the cut is not completed or where the fill is not completed, it can be kept reasonably smooth by operating a grader constantly over it as the material is being cut and filled.

The most striking difficulties encountered in keeping roads open during construction are the short detours around culverts and bridges. In the case of bridges, wherever the alignment permits, it is much better to build the bridge on a new site even at the cost of a few hundred dollars additional, and permit the traffic to use the old bridge rather than a temporary structure. In quite a number of cases curves occur near bridges, and it is possible by a new alignment at the point to build a new bridge and maintain the old one during construction.

In the case of culverts, instead of detouring the traffic across the ditches and through fields, which usually are impassable after each rain, we should build the culverts in two sections. While it is slightly more costly to do this, the additional cost is made up many times in savings to the traffic. We have experimented with this method during the last season and our plans and specifications for next year will call for the construction of culverts in two sections wherever we expect to keep the road open for traffic.

In some of the eastern states roads have been built in halves and the traffic dispatched in a single direction by a system of telephoning. We traveled over sections of highway so handled this year, and it was our impression that for a main line of traffic this method was unsatisfactory and that if the money expended in dispatching and in additional cost of construction under such conditions had been spent in temporarily fitting a detour or detours for traffic, the result could not but be more satisfactory, unless there were positively no detour available. Conditions under traffic so carried on Sundays and legal holidays must, indeed, have been serious.

Detours Should Receive Careful Attention

Where highways under construction are to be absolutely closed careful attention should be given to the

detour. If possible, the road over which the detour is to be carried should be given the proper amount of attention the preceding year. Nothing is more exasperating to the motorist than to be detoured along a certain highway and to find it has been recently graded to be ready for the detour and is, itself, as impassable as the highway from which the traffic has been diverted. A little more care and attention given in advance to detours will pay heavy dividends in satisfaction to the traveling public.

Where opportunity exists it is much better to provide a detour for one line of traffic, and to use another highway for traffic going in the opposite direction. If the roads selected for the detours are narrow, this avoids many complications in meeting and many accidents, and facilitates the passage of both lines of traffic. Furthermore, the detour roads are not quite so thoroughly damaged if the traffic is halved. We feel that where there is any question of reasonable doubt the double detour should be used.

Needless, to say, detours should be signed and maintained. Signing detours does not mean just pointing an arrow at the first turn away from the road under improvement. It means a consistent series of signs, directing traffic adequately from beginning to end of the detour. There is no more helpless feeling than that which comes to one lost on a supposed detour at midnight, possibly with the rain descending, and all the farmers in the neighborhood gone to bed. If all of our engineers and contractors had been caught in such a predicament (as I have been) there would be much greater care used in the selection, maintenance, and signing of detours than is now generally exercised.

A good many present-day highways must be detoured when constructed. It is practically impossible to construct a concrete road without detours. The name is true of almost every road except graveling and grading jobs. But the cost of detouring is a very heavy charge upon the traveling public. Almost invariably the detours are longer than the road under construction, and if the road under construction is a heavily traveled one, the cost to the traffic of making a detour, even one mile longer than the straight road, is very heavy. For instance, a detour 3 mi. longer than the main road, carrying a traffic of 800 vehicles a day, means a daily total of extra travel of 2,400 mi., which even at 10 ct. a mile is $240 per day. If the road under construction is kept closed for 4 months, the cost of detouring will be $28,800, and unless the structure is of such a character as absolutely to preclude taking traffic through, any reasonable expenditure in keeping it open for traffic can be seen to be fully justified.

Whether to detour or not is a matter of especial consideration for each particular set of circumstances. Detours should certainly be kept to the minimum both in number and in lenght, and where necessarily used should be made as safe as possible and as unmistakable as foresight can make them.

Danger Signs Should Be Used Only for Actual Danger

Much can be done to promote safety in highway use by the erection of proper signs at places which are really dangerous. All railroad grade crossings should, of course, be posted. Many states have uniform signs and uniform posting laws. The white circular disc with two black division lines and the letters "R. R." is now practically standard, and inasmuch as its use is so general it should be made universal. All sharp turns should be signed; also school-houses, approaches to principal highway crossings, and all other places where the operator of a car should have it under full control.

The flashing signals on the market are good but so expensive as to practically prohibit their use, because when such signals are used they should be used universally or else they add to the danger rather than lessen it. When considered from a statewide standpoint the millions of dollars involved, put them out of the question for the average state.

Dead ends and very sharp turns which are unavoidably present should be boarded across the end with a white sign board, with an arrow indicating the direction of the turn.

During construction green flags should be used by day and green light by night to give advance warning of danger ahead. The actual point of danger should be red-flagged and red-lighted at the point of repair or replacement. A single red light at the structure or place of repair is not sufficient on high speed roads, because often these are mistaken for the rear lights of other motor vehicles, and even when not so mistaken the driver sometimes cannot stop before striking the obstruction. There has been too little use of caution signs well in advance of danger, and practice in this respect should be improved.

Care should be exercised in erecting signs indicating danger that they are not erected where, in fact, no danger exists, because the constant passing of danger signs when no danger is later apparent makes drivers careless and has the effect of the cry Wolf! Wolf; and finally when actual danger is encountered disaster ensues.

Incident to the use of proper guiding and warning signs is the very advisable removal of all advertising signs along highways, especially those which interfere with vision. We are of those who believe that our highways are no place for advertising. Heaven knows there are enough avenues of publicity open to those who wish to sell their goods without making our rural landscapes a futuristic nightmare. The total elimintion of such signs is coming very fast and this reform will probably do more to add beauty to our highways than any other single thing. If manufacturers understood that instead of adding to their trade, these signs

(Continued on Page 144)

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

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E. L. POWERS
Editor

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Copy for advertisements must reach the New York office by noon on Tuesday of the week before date of issue if proofs are to be submitted.

Copy for classified and other advertisements where proofs are not required will be accepted until noon on Monday of the week of issue.

Articles by road builders are solicited. They should be short and, if possible, accompanied by photographs. Those accepted will be paid for at current rates.

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SAFETY AND BEAUTY IN ROAD DESIGN

Highway engineers are no longer content with devoting all their attention on the making of the most durable structure possible. Indeed, they are at the present time giving particular attention to matters outside the mechanics of road construction. In another part of this issue appears an article by A. R. Hirst, State Highway Engineer of Wisconsin, under the caption, "Safety and Beauty as Factors in Road Design and Construction." In this article Mr. Hirst says that "those highway officials who were concerned in the design and construction of highways prior to 1900 were fortunate in that they had to pay little attention to many factors which now materially complicate the design of modern pavements. Then it was sufficient to grade well and drain a highway and place a macadam surface of narrow width, and about the only element of risk was the danger at unseparated railway crossings. In designing highways for present day traffic, the engineer is confronted with a much more intricate problem. Not only must he design highways which will withstand traffic, but he must design them to be safe, and at the same time he must try to meet modern ideas of the esthetic."

ROAD WORK IN MARICOPA COUNTY, ARIZONA

To the minds of many people Arizona is the land of cowboys and cactus—the setting for many of our modern novels. Yet one of the counties of Arizona, Maricopa County, has a highway program which surpasses the highway programs of many states. From Nov. 1, 1920 to Jan. 15, 1922, a period a little greater than one year, this county constructed 124.4 mi. of concrete highways at a total cost of four million dollars. This is a record of which many states could be proud.

Last month bids were received by Maricopa County for the construction of 168 mi. of additional highways, to be constructed at a cost of four and one-half million dollars. When this additional mileage is completed Maricopa County will have without question the finest system of county highways in the country.

ROAD WORK IN 1921

During the past year a total of $600,000,000 was expended for the construction and maintenance of roads in the United States, according to estimates of the U. S. Bureau of Public Roads. Of this amount only 14 per cent was federal aid money. It is very often the impression, even among highway engineers, that federal aid funds constituted a large proportion of the funds used in road work in this country, whereas such is not actually the case. Revenue from motor vehicles constituted 19 per cent of the funds used in road work last year. Motor vehicle interests are fond of pointing out that automobiles bear the greatest burden of road construction and maintenance. These figures of the Bureau of Public Roads show that such is not the case and that motor vehicle fees comprise only one-fifth of the total funds used in road work in this country.

Other sources of road funds during the past year were as follows: local road bonds, 33 per cent; county and district assessments, 14 per cent; state taxes, 12 per cent, and state bonds, 7 per cent.

LOW COST ROAD SURFACES

The use of local materials whenever possible is being advocated by highway engineers in all parts of the country. "In selecting the surfacing material, the engineer is governed by finances," says William N. Bosler, Principal Assistant Engineer of the Kentucky Department of State Roads and Highways, in an article elsewhere in this issue. "It therefore becomes incumbent upon us to thoroughly investigate and utilize to the utmost local road building materials for our road surfaces. As a matter of fact a road built of native materials, if properly maintained, is a better road for every purpose than one which is constructed of much better material at a greater cost but which is not properly cared for. In the use of local material by increasing the thickness at the surfacing section we can secure a more economical improvement than by importing materials from other states."

SAFETY AND BEAUTY AS FACTORS IN ROAD DESIGN AND CONSTRUCTION

(Continued from Page 142)

serve to lessen it, their passing would be only a matter of a very few years, and they can be made to understand this by a proper campaign of education and warning.

The division of roads by center line marking, especially at curves, is a growing practice. There can be urged against it the objections that it serves to concentrate traffic too much, and that it also keeps traffic constantly near the edges of the road slab, thus encouraging corner breaking. I feel that its expediency is very debatable on straight stretches of highway but that on curves it should be universally used. The possibility of indicating turns, road intersections, and approaching danger on the road surface itself, has not been thoroughly worked out but we feel that there are decided chances of advance along this line. The good driver is always watching the road and can readily note such signs if they can be kept clearly marked.

Proper Maintenance Also Contributes to Safety and Beauty

Something can be done for both safety and beauty by proper maintenance. Signs should be kept clean and repainted as often as necessary. The discreet use of paint and whitewash on guard fences, limiting stones, and signs add much to the attractiveness of a road. Brush interfering with vision at corners should be kept well cut. The roadside should be kept mowed.

It should not be assumed that just because detour signs have been placed they are going to remain perpetually as placed, because the American small boy and other vandals with less excuse are always with us. Engineers usually go through the work itself and very seldom use the detours, and we have discovered cases where practically all signs were down on detours without the men directly in charge knowing it, because they never used the detour but went through the work. Detours should be in charge of the maintenance department and not the construction department, and the maintenance engineers should be required to travel the detours.

Build safety into the structure by proper design. Do not expect to provide it by large expenditures of paint and signs after blunders are made. Without proper design, maintenance can do little toward providing safety except in cases of disaster to the road structure. Maintenance can, however, assist in beautification by providing well kept surfaces, shoulders, and ditches, and by keeping all signs and attendant structures well painted or clean. In one way, by keeping shrubbery and trees cut so that they will not interfere with vision, maintenance will add to the safety of the road.

KNIGHT LAW HELD UNCONSTITUTIONAL

The Court of Appeals of New York State on Feb. 28 handed down a decision declaring the Knight Law of 1919, giving contractors for the construction of highways relief from unprofitable contracts made when the United States entered the war to be unconstitutional in a test case brought by John H. Gordon, Albany contractor. The war permitted the cancellation of war time contracts and authorized contractors to recover against the state for increased cost of labor, materials and transportation due to the state of war. Nearly 300 claims have been filed under the law aggregating about three million dollars.

The Gordon claim for $10,139 was presented to the court of claims by the State Road Builders' Association and the court held the law to be in violation of the state constitution prohibiting the granting of extra compensation to public officers or contractors. The appellant division fourth department reversed the decision of the court of claims and its ruling is now reversed by the higher court and that of the court of claims sustained.

ALABAMA PASSES $25,000,000 BOND ISSUE

The State of Alabama recently passed a $25,000,000 bond issue to provide funds for the construction of a state highway system. The measure was passed by an overwhelming favorable vote. Plans are being prepared by the State Highway Commission to go ahead with the work as rapidly as possible.

SOUTH AMERICA WILL BUILD ROADS WITH MACHINERY MADE IN U. S.

Hundreds of tons of Austin machinery will shortly begin to move through New Orleans to Brazil, where it will be employed in public work for the City of Sao Paolo. Robert Morris, head of the Austin Machinery Corporation, of Louisiana, has been in Brazil for several weeks working on this deal, which he recently succeeded in closing at a price of $4,000,000. As this is merely the first in a series of municipal improvements to be undertaken, involving the outlay of several more million dollars, Mr. Morris is camping on the ground in the hope of landing other contracts, and thus creating new openings for Austin equipment. If he is successful, the company will probably establish a branch in Brazil, either at Sao Paolo or at Rio.

The Austin company has already done considerable business in Mexico. With Brazil now lined up on a big program of construction, the company proposes to cultivate the entire Latin-American field, believing that it will afford a market of steadily increasing importance.

The State of Utah plans to construct one hundred miles of roads this year, at a total estimated cost of $2,500,000.

The Construction and Maintenance of Low Cost Road Surfaces*

By WILLIAM N. BOSLER†

The field engineer upon starting upon the survey should be governed only by two points, the beginning and end of the project. Local influences and wishes should not be allowed to dictate the road to pass everybody's front door. As a matter of fact we have today too much evidence of this past interference in the location of our highway systems throughout the country. The engineer on location must be somewhat of a futurist, that is, he must visualize future traffic and urban development of the community due to the new highway. He must study the topography and establish the most direct, practicable, serviceable and economical route within the recognized limits of alignment, curvature and gradient; he must be thoroughly conversant with the geological formations in order to properly lay the grade line and typical cross sections; he must carefully note the watershed areas and subsoil conditions to correctly recommend the proper sized drainage structures and foundation sections for the road surface; he must take a complete material survey to determine the quantity and quality of local deposits of road building materials. In a few words the field engineer not only locates but must plan for construction and prepare for future maintenance. It is my personal opinion that the competent locating engineer must necessarily know construction as well as maintenance of highways. In fact location work offers the greatest opportunity to display real engineering ability in highway work, as there is a greater chance to save money by proper location than any other phase of road work. Personally I have never seen a correctly located road that cost too much. It is better business policy to first locate properly and construct as a grade and drain improvement to be followed later by surfacing than to attempt to spread surfacing by sacrificing location because, in the final analysis, the location is one of the few permanent features of the road. In this connection I desire to state that only permanent drainage structures should be constructed regardless of the type of road surface.

Now let us assume that we have built a properly located and drained graded earth road. From a purely construction viewpoint it is far better to allow the road to be seasoned at least one year by traffic and to permit slides to become stable before placing the surfacing. An earth road properly maintained is not a bad riding surface and by this method of procedure you have the additional advantage of time in detecting subgrade failures before placing an expensive surface. An earth road can be kept in good riding condition if the following rules are kept in mind: First, drag after every rain but never when the mud is in such condition as to stick to the drag and spread unevenly; second, drag early and often. If the drag cuts too much shorten the hitch; third, do not increase the crown by throwing too much material to the center. To prevent this set the drag straight and throw the material to the sides.

In selecting the surfacing material, the engineer is again governed by finances. The traffic census, future development and local road building materials should be given due consideration in the design and selection of the road surfacing. I am a firm believer in the merits of all road paving materials on the market today when used within the proper limits of traffic and precept of design. However, I do not believe there is any highway authority, regardless of his experience, that can conclusively prove that any known type is permanent and should be universally used on our main trunk highway system. If investigations are carried far enough existing failures will be found in all types of pavement and this is not necessarily due to the material itself but can be caused by faulty design, excessive traffic or poor construction. Again because a certain type of surfacing is successful in Maine or Texas does not warrant that it would prove the same in Kentucky. Difference in topogrtphy and climatic conditions also enter into the selection of road surfacing material. Naturally the taxpayer will demand the best returns in service for money expended by the public official on roads as he does in his private investments. It therefore becomes incumbent upon us to thoroughly investigate and utilize to the utmost local road building materials for our road surfaces. As a matter of fact a road built of native materials, if properly maintained, is a better road for every purpose than one which is constructed of much better material at a greater cost but which is not properly cared for. In the use of local material by increasing the thickness of the surfacing section we can secure a more economical improvement than by importing materials from other states. The first or original cost will be less and during construction additional material can be stored on the site of work at a reasonable charge to care for future maintenance. In certain sections of the state we have an abundance of creek, bank and river gravel, limestone, sandstone and slag of good quality. In Western Kentucky owing to the availability of material we have constructed a large mileage of bank gravel and clay gravel roads and should continue to do so, for although not a perman-

*Paper presented at Highway Convention at University of Kentucky.

†Principal Assistant Engineer, Kentucky Department of State Roads and Highways.

ent type it proves, with proper maintenance, to be very serviceable and a good return for the money invested. The real secret of success with any gravel road is the ability to keep just enough moisture in the road; too much water is no worse than too little. The surface of gravel roads can be kept in first class condition under reasonable traffic by dragging. This is very important and requires excellent judgment. The maintenance man must know from experience when the surface is in the right condition to drag, how much crown is best for the surfacing material and above all must be willing to get results at one operation. Incompetent men on gravel maintenance mean wasted money and no results. More depends upon the execution of the work and experience of the man in charge than upon the methods used. A roadway should be kept uniform in cross section from ditch to ditch not only to prevent water damage but also to distribute the travel so as to eliminate ruts. Concentrated travel on one section of surface will soon wear out a gravel road. If experiments now being conducted by this Department, namely, surface treating gravel roads, prove successful we are of the opinion that maintenance cost can be reduced and the life and serviceability of this type greatly increased.

What has been said of gravel construction in western Kentucky is equally true of waterbound, limestone and slag macadam in central and eastern Kentucky. Our local material for limestone macadam is of a varying quality but when properly constructed and surface treated gives excellent satisfaction. It is the policy of this Department to surface treat all limestone macadam with a bituminous carpet treatment one season after original construction, it being our practice to apply carpet treatment in two applications: a prime or light coat followed by a second or medium coat of bituminous material. Frequent applications of light material and small gallonage give better results than heavy material and large gallonage. Too heavy a bituminous carpet is worse than one too light. It is our general practice to construct waterbound slag macadam in detail as a limestone macadam and likewise to surface treat new construction after being thoroughly seasoned by traffic. In some sections of eastern Kentucky we have a local deposit of sandstone which we utilize as a hand-napped base course supplemented with waterbound limestone macadam top or wearing surface. This also has proven economical and a satisfactory road surface when given the customary surface treatment.

The next subject for consideration is reconstruction. Ordinarily speaking the general alignment of the existing road surface must be followed because of permanent land improvements, however, changes in curvature, gradient and small revisions in alignment, installation of new drainage structures and additional right of way will be found necessary to improve the safety of traffic. As regards design the depth of existing surfacing material is generally considered as having a value of 50%. Additional new surfacing must be added to bring the compacted thickness to the requirements. Scarification and reshaping are necessary to produce the required cross section, then the usual method of constructing the type in question, all of which is to be followed by a bituminous carpet treatment. A great many miles of waterbound limestone macadam roads in this state that are considered by laymen to be practically worthless could have been saved in the past by the proper maintenance methods, but unfortunately at that time such matters came within the jurisdiction of the county and was neglected to such an extent that what could then have been resurfaced now has to be reconstructed and costs nearly as much as original work. A few words to the county officials regarding this matter may not be amiss. Consider your highways in the same attitude as a railroad company views its property. As soon as it is constructed start maintaining and keep maintaining as long as the road is to be used as such. If you would only spend one-half in maintenance of what you will lose by not maintaining, your roads would all be good and at the end of ten years' time you will have something to show for your money besides sad experience and depleted highways. Do not discard your present roads because they are badly worn. Salvage and revive them and get useful mileage rather than attempt too much high and costly types of surfacing. Your original investment should by all means be saved whether the road be earth, gravel, slag, or limestone. I am afraid we are too prone in this day of fast vehicular travel to demand the costly and easy-riding surface and in many instances discard what would prove useful. We cannot all live in stone or brick mansions and ride in Pierce-Arrow limousines. Consider the money invested in original construction, plus interest on same, plus yearly maintenance necessary to produce a serviceable road for the demands of traffic when comparing types for the purpose of selecting and answer your own local questions.

In the final summation my personal belief leads me to say that 75% of the traffic in this state can be served satisfactorily for the next ten years by construction using local materials, surface treating and properly maintained. Understand me correctly, I do not wish to discourage construction of high type road surfacing, but I do wish to avoid breaking our financial back for mere appearance's sake. The day has unquestionably come when higher types of road must be built but what Kentucky needs now is a larger mileage of surface roads rather than a small mileage of high-priced highways. Unfortunately there is not money available to build all roads at once and we must save our assets as exist in the old pikes until we have the price for new ones. By means of careful patching, constant patrolling and surface treating, it

is possible and not too expensive to save money on old roads. As additional money becomes available resurfacing can be carried on and eventually everyone will have a good road.

If we want to spend money properly, invest in the very best location and installation of permanent drainage structures and place thereon a surfacing of local material adequate for traffic which can be maintained as a serviceable road at a minimum cost. Most any engineer with unlimited funds can locate, design, construct and maintain a costly improvement, but it requires real engineering ability to use native materials, adapt them to local conditions and serve the people economically and satisfactorily.

Disappearance of Paper Profits*

By HENRY H. WILSON†

(Continued from last issue)

The preparation of a bid upon the excavation embraced in a highway contract is believed to be one of the most prolific sources for the disappearance of paper profits. It is doubtful if any other item of a road contract holds such possibilities for loss. In proportion to its relative value in determining profit or loss, excavation probably receives from the average bidder less careful and painstaking attention than any other contract item. Many constructors appear to bid excavation at about what they estimate the actual labor cost of performing it to be, without giving any thought to the fact that it is one of the principal items in almost every highway contract and should properly take care of a very considerable portion of the overhead expense and profit. Paper profits on excavation may disappear through failure to properly appraise any of the following factors.

Classify Excavation Before Bidding

(a) Failure to study all excavation involved in the field and to work out in advance of bidding an approximate classification of material to be handled in grading, foundations, ditches, borrow pits, shoulders, dressing slopes, refilling rock breakage in cuts, etc. Almost any constructor can tell you what the total unit cost of excavation was on a particular job but few can tell how many yards of each of the various classes of material were handled by a particular method and the resulting unit costs. Because of the difficulty and expense necessary to properly keep such costs we not only find constructors' records but the actual technical literature in existence on this particular subject, very barren.

After all pains and technique have been exhausted, however, we are still forced to admit that any estimate upon road excavation will, doubtless, vary more widely from the actual costs experienced than the estimate upon any other item in a highway contract. Under these conditions one might think that constructors would proceed with more caution and be less inclined to flirt with the danger line in bidding on this item than on any other item of a contract, but no such impression can be justified by the history of bids and resulting costs in recent years.

Minor Expenses Count Up

(b) Failure to estimate even approximately on the amount of fence moving, sod, clearing, scarifying and other items which may be included in the excavation price.

(c) Failure to approximate average length of haul or overhaul on excavation and borrow.

(d) Failure to recognize that, on most road construction in cuts it is impracticable not to excavate a large portion of the shoulders and then replace same without payment for either operation.

(e) Incurring heavy demurrage charges through failure to provide for orderly shipment and unloading of materials. The writer heard of one highway constructor in the East who was forced to pay several thousand dollars demurrage in a single season through accumulation of cars due to carelessness in design of the unloading plant and ordering of shipments.

(f) Failure to allow on estimate for expense of stocking and rehandling materials and for waste in materials incident thereto.

(g) Failure to properly figure average haul on materials for pavement, masonry and other items for the work as a whole.

(h) Failure to figure cost of steel bars, pins and filler required for expansion joints.

(e) Failure to figure shrinkage as between loose measure and solid measure in the construction of subbase, broken stone base and other foundation courses.

Masonry Unit Costs Vary Greatly

(f) Failure in bidding on masonry work to recognize the great variation in the unit costs of labor and other expenses as between bridges, walls and other heavy masonry and pipe-head walls. Aside from bridge parapets, the construction of head walls will be found to be comparatively much more expensive than other ma-

*Paper presented at annual meeting of the Highway Division, A. G. A., Cleveland, O., Jan. 18, 1922.

†Winston & Co., Muncy, Pa.

The first installment of this article appeared on pages 131-133 of last week's issue.

sonry quantities not only in labor but also in waste of material as well. As an instance of this on a road project built in 1920 the cost of rubbing down head walls with labor at $4.50 per day, was found to be thirty cents per cubic yard of concrete placed in head walls.

(g) Failure to make proper charge for supplies required in connection with concrete masonry, tile underdrains and other miscellaneous items of contract work.

Conclusion

In conclusion it may be said that there is no royal road either to the best estimating or the prevention of the disappearance of paper profits. To the close student of the subject, however, this fundamental thought should always suggest itself: No matter how many uncertainties may enter into the preparation of an estimate, the moment you eliminate or neutralize one of these uncertainties by careful analysis or study you are correspondingly closer to the actual result than if you guessed at them all.

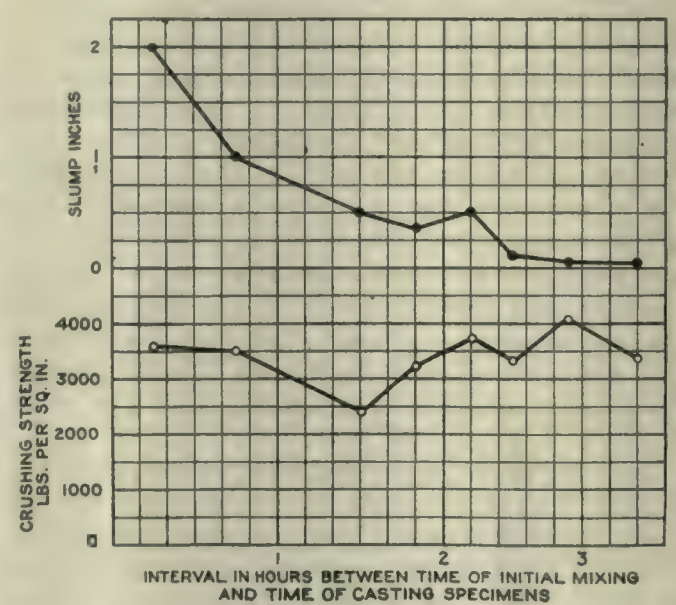
As has been said before, no scheme will ever be devised or charts drawn so that a novice can make highway estimates. By the same token nothing will ever be promulgated or known which will entirely eliminate the disappearance of paper profits. However, through use of brains, intellient interpretation and application of previous costs as well as a cultivation through study of a knowledge of conditions influencing costs, risks can be greatly minimized and a much more accurate and conservative result obtained than is possible by any other human methods. "Every tub must stand on its own bottom." Your aptitude in eliminating the disappearance of paper profits will have to be built on experience and study in the actual conduct of construction.

Central Plant Mixed Concrete Tested for Maximum Safe Haul*

The tests were made primarily for the purpose of determining the probable safe maximum length of haul for central-plant-mixed concrete to be used in the construction of a proposed experimental concrete road near Washington, D. C. The results are interesting, however, in a general way in that they show the relative strength and consistency of gravel concrete when hauled in a wet batch and tested at various periods of time up to three hours after initial mixing. The experiment was made in the following manner: Two batches of concrete in the proportion of 1:1½:3 were mixed in a stationary concrete mixing plant of 1 cubic yard capacity. Potomac River sand and gravel were used as aggregates, the latter graded from 1½ inches to ¼ inch size. An effort was made to mix each batch to a consistency having a slump of about 2 inches as measured by the truncated cone.

After mixing, the concrete was dumped directly into a 3-ton truck, the wooden body of which had previously been divided into six compartments by means of transverse boards equally spaced and each about 1 foot high. The concrete in the two batches was dumped so that each of these six compartments contained approximately one-third of a cubic yard. After making a slump test and casting 6-inch by 12-inch cylindrical specimens for compression test, the truck was run for 30 minutes, when the contents of the first compartment were sampled for consistency and strength. The concrete in compartment No. 1 was not dumped at this time but was sampled in the truck, every effort being made to secure average samples. The truck was then run to the Arlington Experimental Station, a distance of 3 miles, where the contents of compartment No. 1 were dumped. Inasmuch as a dump body was not available for this experiment it was necessary to shovel out the concrete by hand. Its consistency at this point, however, was such that it came out readily and would probably have dumped easily from a regulation dump body. After removing the concrete from compartment No. 1, the truck was run about the station roads for 15 minutes, returning to the starting point and the contents of the second compartment deposited. Samples for both consistency and strength were likewise taken of this material, after which the operation of driving 15 minutes, dumping and sampling was repeated until all of the concrete had been deposited.

RESULTS OF TESTS OF CENTRAL PLANT MIXED CONCRETE



The concrete had been mixed 3 hours and 10 min-

*From "Public Roads."

utes when the last section was removed. By this time it had become so hard that it was necessary to break it up with a pick. Up to section 6, however, it was possible to remove the concrete with shovels, and, although very dry, segregation had not become especially marked. This may probably be accounted for by the fact that the concrete was mixed fairly dry in the first place, the initial slump being only about 2 inches. It has been noted frequently that wet concrete will segregate more quickly and pack more readily during hauling than dry concrete.

Strength Not Affected so Long as Concrete Is Workable

The results of the tests of consistency as well as the 28-day crushing strength tests are given in Table 1. They are also shown in figure 1, in which the slump in inches and the crushing strength in pounds per square inch at 28 days are plotted against the length of haul

RESULTS OF TESTS FOR CONSISTENCY AND CRUSHING STRENGTH OF CENTRAL-PLANT-MIXED CONCRETE

Compartment number.	Total elapsed time.[2]	Slump.[3]	Crushing strength, pounds per square inch.[4]		
			(1)	(2)	Average.
	Hrs. min.	*Inches.*			
(1)	15	2	3,620	3,510	3,565
1	45	1	3,460	3,550	3,505
1	1 30	½	2,670	2,200	2,435
2	1 50	¾	3,510	2,960	3,235
3	2 10	¼	3,820	3,580	3,700
4	2 25	¼	3,110	3,550	3,330
5	2 45	1/16	3,840	4,230	4,035
6	3 10	1/16	3,300	3,370	3,335

1. Test made at plant.
2. Time between initial mixing and sampling.
3. Test made with truncated cone 12 inches high and with top and bottom diameters of 4 and 8 inches, respectively.
4. Tests made on 6-inch by 12-inch cylinders of 1:1½:3 concrete at age of 28 days.

in hours. It will be noted that, whereas the concrete became very dry after about one hour's haul, the strength of the cylinders prepared from the various batches was about the same. In only one case was the strength much below the general average of 3,500 pounds per square inch. This was noted in the case of the cylinders made from the concrete in compartment No. 1. Nothing in the appearance of the concrete at the time these cylinders were cast would account for the difference in strength. All of the specimens were made as nearly as possible in accordance with the recommended practice of the American Society for Testing Materials for taking field specimens of concrete, but as the concrete in the last three compartments was so dry as to show practically no slump it was necessary to use considerably more pressure in preparing the cylinders representing these sections.

The appearance of the concrete during the experiment would indicate that it could have been handled by a concrete pavement finishing machine at any period up to two hours after mixing. It became too dry for hand finishing, however, 45 minutes after mixing. Assuming that a wetter mixture would have segregated more quickly, especially with a gravel aggregate, the experiment indicates that the most practical way to utilize the central mixing plant in concrete road construction is in connection with a machine finisher. It also indicates that so long as the concrete is workable after a period of hauling, the strength will not be affected.

As previously noted, this experiment was made simply in order to obtain some idea of the behavior of certain aggregates when handled as central-plant-mixed concrete. It is the intention of the Bureau of Public Roads to make a somewhat extended investigation of this subject in the near future, using a variety of aggregates and consistencies.

MARICOPA COUNTY, ARIZONA, RECEIVES BIDS

Bids were recently received by Maricopa County, Arizona, for the construction of 168 mi. of road under the proceeds of its second bond issue, amounting to $4,500,000. Twohy Bros., who held the contract for the work done under the first bond issue of $4,000,000, was the low bidder on concrete pavement, bidding $2.31 per square yard for 6 in. pavement, and $2.02 for 5 in. pavement.

WISCONSIN HAS BIG ROAD PROGRAM

Funds available for road construction and maintenance in Wisconsin for 1922 are as follows:

Federal aid construction	$ 6,000,000
State aid construction	13,800,000
Non-state aid construction	2,000,000
Maintenance	4,500,000
Total construction	21,800,000
Grand total	26,300,000

The State of New York spent $28,775,886 on road construction in 1921, breaking all records for highway construction in the history of the state.

The Famous Storm King Highway in New York has been graded and it is expected that it will be formally opened in July.

The New York Central Railroad has started an action to recover $22.50 from the State of New York. Last November crushed stone owned by the state was dumped on the company's tracks and a car was derailed after the stone was dumped.

A Bill Will be Introduced in the New York Legislature providing that state highways shall be cleared of snow and kept open for traffic all the year. This bill is approved by State Highway Commissioner Sisson. The state has distributed 600 trucks in 57 counties and under this bill every county must keep highways open during the winter.

MEETINGS

Calendar of Coming Meetings

June 4-6—American Association of Engineers—Annual convention, Salt Lake City, Utah. Secretary, C. E. Drayer, 63 E. Adams St., Chicago, Ill.

June 26-July 1—American Society for Testing Materials—Twenty-fifth annual meeting, Atlantic City, N. J. Secretary, C. L. Warwick, Engineers' Club Bldg., Philadephia, Pa.

IOWA ROAD CONFERENCE

The tenth annual Iowa Road Conference will be held on March 22 to 24 at Ames, Ia., at the headquarters of the State Highway Commission. It is expected that a large number of county and town officials and engineers will attend to discuss the various matters to be considered at the conference.

STANDARDS COMMITTEE ELECTS OFFICERS

At the annual meeting of the American Engineering Standards Committee held in New York on Feb. 9, Albert W. Whitney, a representative of the National Safety Council, was elected chairman, and George C. Stone, a representative of the American Institute of Mining and Metallurgical Engineers, was re-elected vice-chairman. Mr. Whitney is Associate General Manager of the National Bureau of Casualty and Surety Underwriters. Mr. A. A. Stevenson, the retiring chairman, is a representative of the American Society for Testing Materials.

PERSONAL MENTION

A. H. Chambers has resigned as city engineer of Logan, Utah.

Fred W. Thomas has been appointed city engineer of Logan, Utah.

Charles H. Moorefield has resigned as state highway engineer of South Carolina.

F. W. Branin has been appointed assistant engineer of Burlington County, New Jersey.

P. D. Mold has resigned as county engineer of Carlton County, Minnesota, to go with the Minnesota State Highway Department.

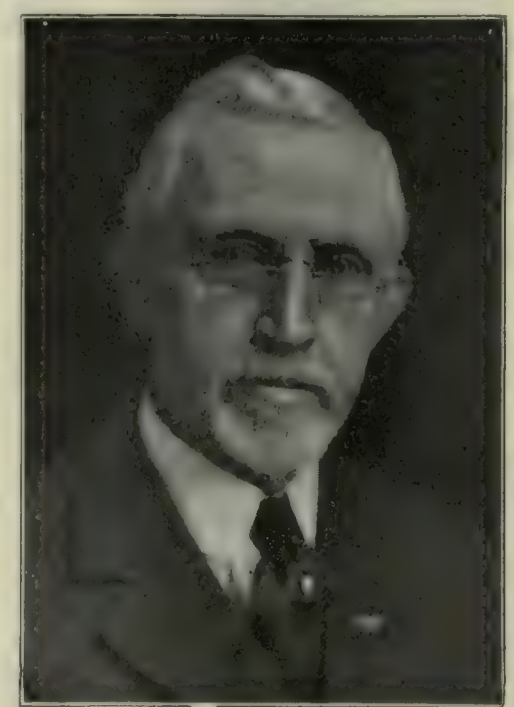
F. S. Crecelius has been appointed division engineer of the Texas State Highway Department, with headquarters at San Antonio.

Daniel A. Young, an employee of the New York State Highway Department for 12 years, has been appointed state engineer of Vermont.

W. M. Spann has been appointed engineer of surveys of the Montana State Highway Department. Mr. Spann was formerly district engineer of the department.

OBITUARY

William C. Sargent for 22 years secretary and also a director of the Chain Belt Company, Milwaukee, Wis., died suddenly on Feb. 5 as a result of heart failure. He was 73 years of age and has been in ill health for several years.



WILLIAM C. SARGENT

Mr. Sargent, prominent in industrial circles of Milwaukee and St. Paul, had a wide national acquaintanceship. He was born at Troy, N. Y., in 1849. In 1871 he moved West, locating at St. Paul, where he organized the De Cou, Corliss and Sargent Company, manufacturers of sash and doors. He later became affiliated with the St. Paul Harvester Company where he met C. W. Le Valley who later founded the Chain Belt Company, of Milwaukee. This meeting was the beginning of a long business association for in 1900 Mr. Sargent went to Milwaukee to become secretary and later a director of the Chain Belt Company. He was also a director of the Federal Malleable Company, West Allis, Wisconsin. His father was one of the founders of the Terre Haute, Alton and St. Louis Railroad.

Mr. Sargent established many of the early business connections of the Chain Belt Company many of which are still among the Company's jobbers.

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

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TABLE OF CONTENTS

*Results of Highway Research Conducted by Illinois. By Clifford Older 151

The Coordination of Highway Interests. By William Ord 160

Massachusetts Would Raise Motor Fees 163

Eighteen-foot Bridges the Rule on Federal Aid Roads. 163

Foreign Engineers Inspect American Road Construction. 163

Wider Highway Tendency Shown in Road Building. 163

Unusual Drainage Problem Solved. 164

Makes Automatic Tests of Road Building Materials. 164

Police Patrol Connecticut Roads. 164

Film Shows Use of Brick in Roads. 164

EDITORIALS:

Experimental Work in Illinois. 161

Highway Safety Instruction. 161

1922 Will be a Big Year. 161

Alabama Passes $25,000,000 Bond Issue. . . . 161

MEETINGS:

Calendar. 164

PERSONAL MENTION. 164

*Illustrated article.

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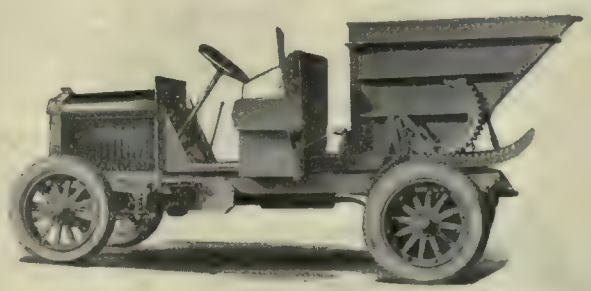

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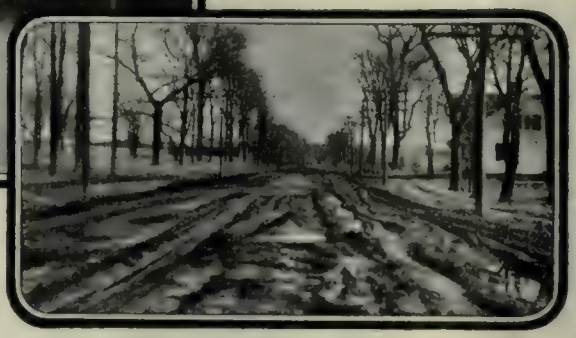

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CONSTRUCTION TRANSPORTATION MAINTENANCE

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THE HIGHWAY CONTRACTOR AND ROAD BUILDER

Vol. LXII. NEW YORK, N. Y., MARCH 15, 1922 Number 11

Results of Highway Research Conducted by Illinois*

By CLIFFORD OLDER†

Early in 1920, Governor Frank O. Lowden, in conference with Frank I. Bennett, Director of the Department of Public Works and Buildings, S. E. Bradt, State Superintendent of Highways, and the writer, decided that the State of Illinois was justified in undertaking the construction of an experimental road of unprecedented magnitude. This decision was based on the fact that Illinois then had in contemplation the expenditure of possibly one hundred million dollars in a road improvement program. To undertake a program of this size without definite scientific knowledge of the behavior of certain pavements under truck traffic and rural conditions—without knowing definitely how to design pavements to sustain truck traffic was considered unwise. The result was the construction of the Bates Experimental Road.

The Bates Road was started in 1920 and was finished in 1921. The completion of the project and the continuance of investigations in connection therewith were heartily endorsed by Governor Small.

This paper gives a summary of the results of the scientific research which has been carried out, both as to the construction and subsequent behavior of this road.

Since the last of October, 1920, an average of ten investigators have been occupied in research work. An enormous volume of data has been collected, and preliminary analyses made. It would obviously be impossible to give in detail all of the data collected. Typical illustrations in the way of photographs and diagrams will be used to show conclusions which may reasonably be deducted from the data obtained.

Subgrade Moisture

For more than a year subgrade samples for the determination of moisture content have been collected periodically from several hundred stations located along the Bates Road and along about 60 mi. of paved highways adjacent to Springfield.

In Fig. 1 is plotted the moisture content curve of the subgrade of the Bates Road. The moisture content is expressed as a percentage of the dry weight of the soil. The soil in this case is the brown silt loam of the Mississippi Valley Corn Belt. It is a finely divided material that ordinarily would be called a clay soil. The sampling stations in the Bates Road were established in positions such that the results would show any variation which might occur in the moisture content, due to the proximity of the station to the edge of the pavement, to cracks and to joints, as well as in areas as far removed from such features as possible. It soon developed, however, that the moisture content of the subgrade soil in proximity to edges and cracks was at no time materially different from that observed elsewhere. This conclusion has been checked from time to time up to the present date. This condition might not prevail in localities where prolonged rainless seasons occur. A further observation of interest in this connection is that at the point in the Bates Road where a tile drain with a cinder backfill was laid 30 in. below each edge of the pavement for a distance of 200 ft., the moisture samples show no variation from those obtained elsewhere.

About eight miles from the Bates Road a section of pavement, 1,000 ft. long, was selected for a drainage experiment. Tile drains were laid immediately under each edge of the pavement a depth of 36 in. below the bottom of the slab. The trenches were back filled with cinders and sampling stations were established throughout the 1,000 ft. The moisture content of the soil under this section has been uniformly lower than that under the Bates Road. However, it is believed that this result is due to the difference in the character of the subgrade soil (which is a yellow clay) rather than

*Paper presented at annual convention of the American Road Builders' Association.

†Chief Highway Engineer of Illinois.

to the effect of the tile drainage. This conclusion is deducted from the fact that moisture samples taken from the subgrade of undrained sections, where the soil is of the same nature, also shows a lower moisture content than that under the Bates Road and approximately the same as that of the tiled sections. A sufficient number of samples from undrained subgrades having soil of this character has not as yet been tested to make this conclusion positive.

Prof. Eno, in a paper read before the 1921 convention of the American Road Builders' Association, brought out the fact that certain clay soils of Ohio when moulded in a moist condition resisted to a marked extent the further absorption of moisture, while the same soils after having been dried, disintegrated rapidly when placed in water and absorbed a much larger volume of water in a short period of time. It seems probable that this is true of many if not all clay soils; and no doubt accounts for the rapid saturation of the Bates Road subgrade in the fall of 1920, as a large portion of the pavement was laid on an air dry subgrade. Within three days after the fall rains started the subgrade was found to contain the high percentage of moisture indicated in this diagram. It is to be noted that more than five months during the summer of 1921 the moisture content varied less than 5 per cent although frequent rains occurred. At the present time the moisture has again reached a high figure but the increase has been gradual.

In order to determine the possible rate of saturation of the subgrade from the edges to the center, in July a trench was cut along the edge of the pavement and kept filled with water for some days. At first this trench was cut immediately against the edge of the slab, but as the warping of the pavement due to changes in temperature (described later), immediately permitted sheets of water to flow under the pavement it was impossible to obtain the desired results. Later, a trench, about 1 ft. from the edge of the pavement, was cut at a different point, leaving the shoulder undisturbed between the edge of the trench and slab. This trench was kept filled with water for a period of three weks. Although the nearest sampling stations were only 30 in. from the edge of the trench, the moisture content of the subgrade at these stations showed no increase and no variation from that at other points under the pavement.

In order to ascertain whether or not the freezing of soil would render it more susceptible to saturation, a number of blocks of the subgrade were cut out very carefully so as not to disturb the natural compaction; then frozen, and after having been thawed out were immersed in water. After freezing most of the blocks fell to pieces upon immersion. Samples that had not been frozen remained practically intact and absorbed moisture slowly. The samples which had been frozen and then immersed in water absorbed moisture at a much more rapid rate. Typical of these experiments. four blocks, when taken from the subgrade showed an average moisture content of 28%; after immersion for 20 hours, the moisture content was increased to 33% or an increase of 5%. Another set of four blocks, having the same initial moisture content, after having been frozen for 6 hours and then immersed in water for 24 hours, showed an average moisture content of 42% or an increase of 14%. From the results of these tests, it seems altogether probable that although a clay subgrade may resist, markedly, saturation from an occasional rainfall, yet the same soil may quickly become saturated after a freeze. An examination of the curve Fig. 1 shows further that although the moisture content has not increased rapidly, yet a high degree of saturation has again been reached, although we have had no freezing weather.

Subgrade Bearing Power

Much time has been spent in an effort to ascertain the factor having influence on the supporting capacity of subgrade soils. Believing that soils might behave differently under repeated loads as compared with loads applied but once, an apparatus was devised and perfected, by means of which loads up to 50 lb. per square inch could be repeated indefinitely on subgrade soils in place. This apparatus was briefly described in an article which appeared in Public Roads, Volume 4, No. 5. The results of its use, up to the present time, have not been entirely satisfactory owing to the apparent difficulty in securing a perfect contact of the shoe with the subgrade soil before a load is applied. No means yet tried have eliminated an initial deformation under a light load comparatively much greater than that obtained under the same load on subsequent applications. However, the use of this apparatus points strongly towards the conclusion that a soil, having a given moisture content, may under repeated loads have a fairly definite elastic limit. For example, on a clay soil subgrade a load of 5 lb. per square inch was applied approximately 1,000 times. After the initial deformation, caused by the first few applications of the load, subsequent applications produced a definite deformation under each repetition with complete recovery as the load was released. The load was then increased to 25 lb. per square inch with the result that progressive deformation continued until a total penetration of 0.25 in. occurred when the test was discontinued. The general behavior of subgrade soils as determined on small areas by this machine was closely confirmed by loading concrete slabs having areas of several square feet, which were cast on the same subgrade. These slabs were loaded repeatedly by means of an hydraulic jack. Even in the case of these slabs which were presumably in perfect contact with an undisturbed subgrade the first few light loads caused permanent depressions. In this connection it should be understood, however, that different points on the same subgrade soil, although having the same moisture content, did not exhibit uniform results. This

perhaps is partially due to lack of perfect contact between the loaded shoe and the subgrade; but most likely to inequalities in the compaction of the subgrade soil. It remains to be determined whether or not a subgrade soil at all seasons of the year, or at seasons when the greatest degree of saturation prevails, may be counted upon to exhibit elastic resistance to deformation when subjected to pressures as great as the lowest that may practically be obtained with economic pavement designs. It is certain that this resistance for the Illinois Corn Belt soil containing at times 40% moisture is very low—probably less than 1 lb. per square inch. For the good of the cause we hope this condition is peculiar to Illinois but we doubt it.

Comparatively little work has been done on soils other than the brown silt loam of the Mississippi Valley Corn Belt. A number of observations, however, on a very finely divided sandy soil shows the same general characteristics with no marked variation either as regards bearing power or saturation tendencies; but this soil contains a considerable portion of clay and might be expected to exhibit materially different characteristics from coarse and clean sand or gravel.

Efforts have been made to determine the bearing capacity of subgrade soils in place when highly saturated; but inasmuch as the bearing power determinator was not perfected until the moisture content of all subgrades available had dropped below 35% and as attempts at artificial saturation of the soils in place failed, no material results have been obtained up to the present time. As the Bates Road moisture curve indicates that Illinois is again about saturated we now hope to obtain the desired information.

Subgrade Uniformity

There were installed in the Bates Road many subgrade cylinders each having a brass disk in contact with the subgrade, and a reference plug screwed in the cylinder in such a manner that measurements taken from the plug to the brass disk would show the relative position of the subgrade and the pavement slab at any time. (For detailed description, see Public Roads, Vol. 4, No. 5.) Throughout the year readings have been taken once each week. The results of these observations are of considerable interest. They show distinctly a periodic separation of the pavement slab and the subgrade due to warping of the slab under temperature changes which will be described later They show, also, to a very marked extent erratic variations due in all probability to uneven settlements of the subgrade. Some of these brass disks show a separation of the slab and the subgrade as much as ½ in. over areas of considerable magnitude. Just how far these areas extend it is impossible to determine, as the spacing of the cylinders is not close enough. At practically all of the observation cylinders, a separation of the subgrade and the slab has occurred at one time or another. This separation by no means can be entirely accounted for by the warping of the slab. The erratic movement of the brass disks relative to the slab would lead us to believe that not only is the slab itself constantly warping, but that the subgrade also, is not stable even although there be no traffic on the road. As the moisture content of the subgrade was fairly uniform for several months it seems hardly likely that this is due entirely to a changing moisture condition. It may be due to changes of temperature; but it would

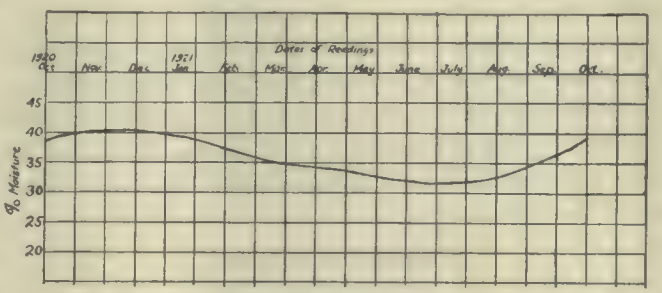


FIG. 1—SUBGRADE MOISTURE INDICATIONS

seem more probable that the operations of grading, plowing, harrowing and rerolling the subgrade did not produce a uniform compaction. No doubt voids remained after harrowing and rolling; and the slacking or breaking down of the soil in a non-uniform manner under different portions of the pavement probably accounts for a large portion of the erratic subgrade movement. In this connection, methods used in preparing the subgrade may be of interest. No heavy grades occur throughout the 2-mi. section; the deepest fill is about 2 ft. and deepest cut about 18 in. After the rough grading was done, the entire subgrade was plowed, harrowed, rolled and wetted the day before the pavement was laid. It is not believed that any economically practical method of compacting a subgrade may be applied with reasonable economy to secure absolutely uniform results.

Frost Action

Observations of frost heaving on the Bates Road were made during the winter of 1920-1921. After these observations were started, only one period of low temperature occurred, at which time the ground became frozen in the open fields and the shoulders of the road to a depth of about eight inches. Precise levels taken from bench marks, carefully protected from frost action, showed a heaving or lifting of the edges of the slab throughout the entire length of the road, at a much more rapid rate than at the center. On sections where a longitudinal joint was provided, the edges of the pavement slabs lifted on an average of about ¾ in., while during the same period the center lifted but an average of about ¼ in. Many sections not provided with longitudinal joints showed approximately the same behavior. All such sections when examined in the spring were found to be cracked longitudinally. A few sections lifted at the edges about ¾ in. and at the center about ½ in.; these sections

showed no discernible longitudinal cracks when examined in the spring. As no loads were permitted on the road during this period, it is evident that the longitudinal cracks were caused by the breaking of the slab under dead load while supported at or near the edges only. If the heaving of the soil due to freezing is universally more rapid under the edges of the pavement than elsewhere, it would appear impossible to avoid the longitudinal breaking of wide slabs, where freezing temperatures occur, especially under heavy traffic. Mathematical analyses indicate that it is likely to be economically impracticable to design wide slabs of sufficient strength to avoid breaking longitudinally when the edges only are supported; hence the present Illinois design provides for a longitudinal joint that in order that erratic longitudinal cracks may be avoided as far as possible.

Temperature Effects

The lateral and longitudinal expansion of a pavement slab, due to temperature and moisture changes, is well appreciated. It is doubtful if lateral contraction or expansion is responsible for longitudinal cracks. It is more probable that such cracks are due to freezing subgrades or perhaps to conditions of support caused by the warping of the slab. It seems altogether likely that contraction due to temperature or moisture changes accounts for at least the first transverse cracks that appear in all concrete slabs.

In the fall of 1920 while attempting to take strain gauge and deflection measurements on concrete slabs under load, the results obtained at first were so erratic as to be useless unless the cause for the erratic behavior could be determined. We undertook one series of tests to determine whether or not the subgrade under a corner of a slab would be compressed under repeated loads to such an extent as to afford no definite support to the pavement. With the apparatus at hand

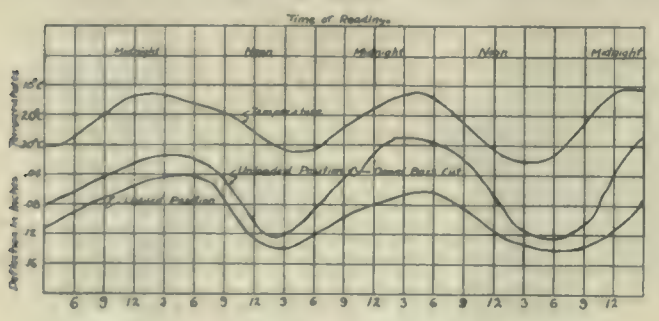


FIG. 2—APPLICATION OF 6,000-LB. LOAD

it was impossible to repeat the loads rapidly and in order to avoid possible subgrade recovery during periods of rest, the loads were repeated continuously for periods of 48 hours. It was then discovered by an examination of the results that at night the slab corner under load might be at a higher elevation than the unloaded corner during the day. We have no knowledge of any previously conducted research work indicative of this important feature.

Fig. 2 shows the air temperature, and the vertical movement of the corner of a 9-in. plain concrete slab loaded and unloaded. This diagram is typical of several hundred all of which show the same characteristics. Hourly elevation readings to thousandths of an inch were taken by means of Ames dials. The 6,000-lb. load was applied to the corner for 3 mi. each hour. Under this load the computed fibre stress in the slab was 220 lb. per square inch. Note that for about two-thirds of the 54-hour period the 3-ton load did not depress the corner of its unloaded afternoon position. It is obvious that the subgrade offered but little if any support for two-thirds of the time.

Fig. 3 shows the curvature of a 7-in. slab on a line bisecting the corner angle. The upper solid line in dia-

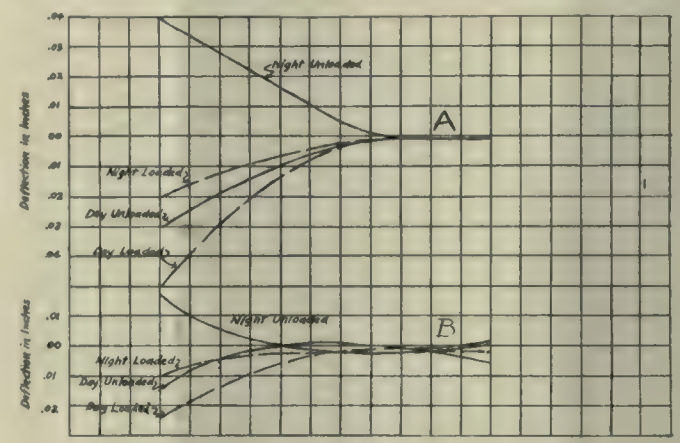


FIG. 3—CURVATURE OF 7-IN. SLAB

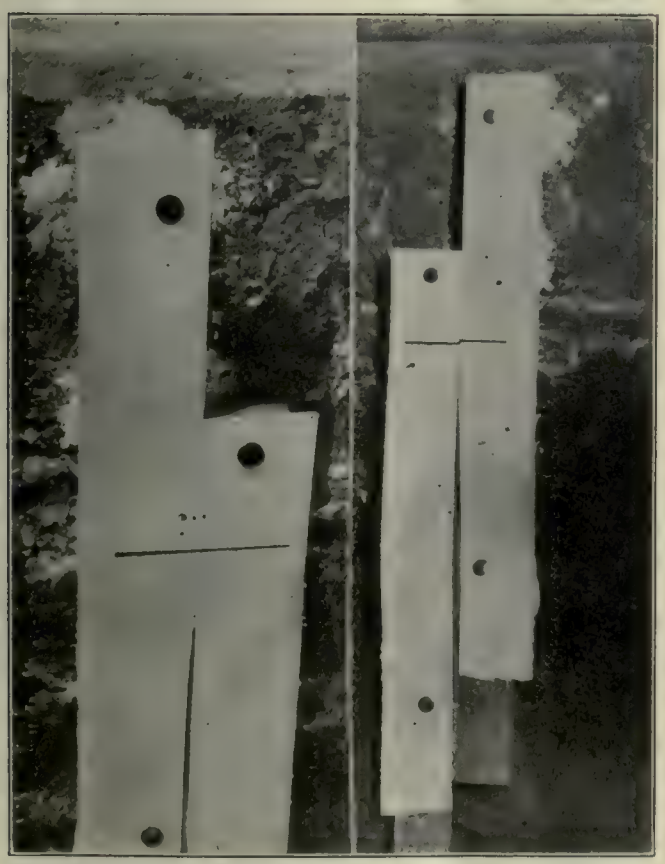
gram A shows the upward warped position of the surface of the slab along a 40 degree line from the corner to the center of the pavement. The upper dashed line shows the position of the slab while a load of 6,000 lb. was applied on an area of 2 sq. in. at the corner. The lower solid line shows the position of the unloaded slab at the point of maximum downward deflection. The lower dashed line shows the position of the slab under the 6,000 lb. load when applied during the day. It is obvious that the slab corner acted purely as a cantilever in supporting the night load. It is also obvious that, as the increased deflection was not as great when the load was applied during the day as when applied at night, subgrade support had some influence on the amount of deflection. The computed fibre stress of the concrete, considering the corner as a cantilever under the night load, amounts to 368 lb. per square inch which is certainly not too low for the working stress of plain concrete. It is obvious that a much greater load with a correspondingly high fibre stress would be required to deflect the corner to contract with the subgrade at night.

Diagram B, Fig. 3, shows the effect under similar conditions of a longitudinal crack or joint. In such cases it is evident that the warping effect does not ordinarily pivot about the center of the full width of the slab, but probably approximately about the center

of the half slab as defined by the longitudinal joint. It is of interest to note, however, that even in this case the upward warping of the slab due to temperature effects was greater than the downward deflection of the slab under the 6,000 lb. load producing a fibre stress of 368 lb. per square inch.

That curling of the edges of an 18-ft. concrete slab may be sufficient to render the most perfect of subgrades ineffective under the edges of the slab may readily be determined without the aid of accurate measuring devices. To visualize this condition the accompanying photographs were made.

Photograph 4-A shows the edge of an 8-in. pavement slab and the subgrade below. The white card on the left is rigidly attached to the slab. The card at the right is fixed to the subgrade at some distance below the base of the pavement. The black line was drawn across the two cards at midday while the sun was shining. Photograph 4-B, taken at midnight, shows a distinct crack in the earth subgrade a short distance below the bottom of the pavement; and shows



4-A 4-B

the offset in the line caused by the upward movement of the slab. A load of four tons on the edge of the pavement failed to close the offset or the visible crack in the subgrade.

By means of the brass disks of subgrade cylinders located in a row across the pavement slab, the relative movement of the slab and the subgrade was confirmed. In many cases these measurements indicated positively that the downward curling of the edges during the day lifts the center of an unbroken slab entirely free from the subgrade near the center. They indicate also a permanent depression of the subgrade at the edges of the pavement under this condition, although a partial recovery occurs as the edges curl up at night. The warping phenomenon is, of course, caused by the more rapid heating and cooling and consequent expansion and contraction of the upper layers

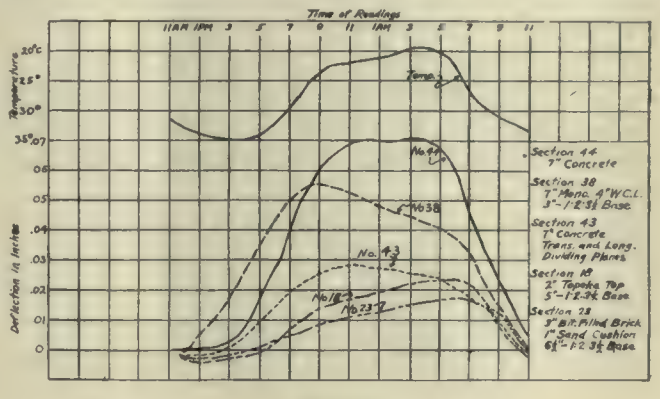


FIG. 5

of the slab. The warping effect occurs much more rapidly on clear, sunny days than when the sky is obscured by clouds. On sunny days the effect of passing clouds may be noticed in the reading of Ames dials set for these observations. Wetting the surface of the pavement has a similar effect. Monolithic brick pavements exhibit practically the same degree of warping as concrete slabs. The effect is much reduced when a bituminous concrete surface is applied, as might be expected. It is similarly reduced when a brick wearing surface having a bituminous joint-filler is used on a concrete base. Fig. 5 shows the edge movement of various slabs. All readings were taken practically simultaneously for 24 hours.

Special attention is called to the slight warping of slabs having plastic surfacing materials of considerable thickness. Such surfacings no doubt tend greatly to reduce the ordinary range of temperature between the upper and lower surfaces of the rigid base, thus materially diminishing the warping of the slab. Under load, pavements of this character would no doubt receive material support from rigid subgrades or subgrades having a high elastic resistance, even under night traffic. The fact that clay subgrades are more than likely to become saturated at times, and when in such condition have very low supporting power, should not be overlooked.

Attention is also called to the comparatively small warping of the concrete slab having a longitudinal joint. Pavements so constructed may also be expected to receive some edge support from good subgrades under night as well as day traffic.

It is evident that the warping of rigid slabs away from the subgrade provides open channels for the free passage of surface water to all parts of the subgrade. Not only was this in evidence when the ditch,

mentioned before, was cut along the edge of the pavement but was observed many times during the last twelve months. Throughout the year with distressing regularity, free water was found in the subgrade cylinders after heavy rains. Further, our latest observations indicate even greater warping effects during the coldest weather that has prevailed this fall than appeared in July and August.

It seems entirely possible that water from rains or melting snow, that finds its way under the edges of a slab as it curls up in the early part of the night, later freezes, thus forming a higher support for the edges and causes an excessive lifting of the entire slab the next day unless it breaks longitudinally under its own weight.

It also seems probable that the formation of ice under the edges at night and under the middle portion during the day is a more reasonable explanation of the presence of layers of ice which have been observed under pavement slabs, than the theory of capillary action.

Impact

Specifications of the Illinois Division of Highways provide that the variation of the elevation of the surface of concrete pavements shall not exceed ¼ in. Some difficulty has been encountered in securing this degree of smoothness especially on grades of more than two or three per cent and on curves. However, the variations are not abrupt and a constant improvement is being obtained. It is believed that the above variation may be reduced materially by more careful construction methods, perhaps aided by hitherto untried equipment. By careful maintenance methods it is believed that the application of crack filler can easily be handled in such manner as to avoid any material differences in elevation from this source. We have as yet not attempted to devise an accurate means for determining the value of impact on average road surfaces. We do have some data which may be taken to indicate that possibly this matter is not of extreme importance—for example, Ames dials have been placed so as to read deflections of the pavement slab, these dials being carried on independent supports. Trucks have been operated past these dials at speeds up to 20 mi. per hour; the trucks were directed so that the rear wheels would pass as close to the dials as possible. During the approach and passage of the load, the hand on the dial was observed very carefully. These investigations were carried out on uncracked pavement sections of ordinary smoothness, adjacent to cracks having the usual jointfiller, adjacent to open joints, etc., yet no movement of the hand of the dial has been observed which would indicate more than a gradual and steady application and release of the load as the truck passed. It is possible that sudden movements occurred which were not observed; but this seems unlikely as a blow of a sledge could easily be detected. Further, in the machine devised to determine the effect of repeated loads on plain concrete beams each repetition of the load occupies one-tenth of a second. In this case the deflection of the beam, as shown by the hand of an Ames dial, is easily distinguished and its magnitude can accurately be determined. These observations are of course but indications of what may occur but point to the prime importance of the development of some means for conclusively setting at rest all doubts as to impact effects caused by roughness of the average pavement slab as now constructed.

All Cracks Not Serious

It may be assumed that a pavement need not be so designed as to avoid all possible cracks or even all load breaks. The usefulness of a pavement is destroyed only when it becomes so broken or disintegrated that it no longer affords a smooth and comparatively unyielding surface. Transverse cracks or joints in rigid pavement slabs may be accepted as inevitable. Illinois for about six years has not provided for transverse joints; yet possibly with the exception of a few roads carrying very heavy trucks and in one unexplained instance, transverse cracks do not average less than about 30 ft. apart. This average covers pavements more than three years old. On two stretches of concrete road in Cook County subjected to very heavy truck traffic, transverse cracks are much more frequent regardless of the character of the subgrade soil or drainage, and longitudinal cracks occur throughout. It seems quite possible that the frequency of the cracks in these sections may be due to the existence at one time or another of comparatively large areas where the subgrade was not in contact with the road slab, as was found in the case of the Bates Road, and represent long breaks. These sections, however, although they are in the main broken up into pieces of from three or four to perhaps 60 square yards in area, are still rendering practically unimpaired service to traffic. While the breaking of the pavement into slabs of large area may be detrimental only on account of appearance and slightly increased maintenance costs yet the breaking down and pulverizing of comparatively small areas at corners and the consequent reconstruction at these places causes serious traffic delays as well as expense. Complete destruction as observed in Cook County is usually confined to a few square feet or at the most two or three square yards and only occasionally do such breaks occur except along the edge of the pavement at corners. The exceptions so far noted occurred at the intersection of a transverse crack with a widely separated longitudinal crack.

Allowable Stress in Plain Concrete

Whatever design formulae are eventually developed, it becomes of great importance to determine what may be a safe working load for plain concrete in tension. An apparatus was outlined by the writer and built in accordance with designs made by Mr. Clemmer, our testing engineer, for determining the effect of re-

peated loads on the transverse strength of plain concrete beams. This apparatus consists of a pair of automobile wheels carried on a horizontal axle which are revolved around a circular track by means of a vertical shaft carrying a pulley operated by a belt from a motor. Load boxes are placed on the axles so that the weight carried by the wheels may be varied as desired. Test specimens consist of 6 in. x 6 in. plain concrete beams, radiating as the spokes of a wheel and cantilevered from a central support. Between the beams, but separated therefrom by one-eighth inch openings, are blocks of concrete flush with the beams so that a smooth track is provided for the passage of the wheels. Seven beams are placed in the machine for each test. The apparatus is so arranged that when any beam breaks a switch is thrown and the motor stopped. By this means the fatigue machine may be operated day and night regardless of the presence of the observer. This apparatus provides also the advantage of having beam ends of sufficient length, after rupture in the fatigue machine for modulus of rupture determinations in a Universal testing machine. As the beams invariably break over the support, the length of the cantilever end is sufficient to make two modulus of rupture determinations on span lengths of 12 in. This is of importance, as the determination of modulus of rupture of similar beams, presumably of the same character as those subjected to repeated loads, is by no means a safe guide as to the strength of the beams subjected to the repeated loads.

The first set of beams were subjected to more than 1,130,000 repetitions of a load which was presumed to be 75% of modulus of rupture of the concrete but which later proved to be but about 37%. As none of the beams failed, the load was increased to about 53% when one beam broke at 43,174 loads; it was then found that the modulus of rupture of this beam was about 1,000 lb. per square inch. Another interesting fact that developed was that five other beams of the same mix, and cast at the same time as the original seven, broke under an average of 60,000 repetitions of the same load when placed in the space left vacant by the breaking of the first beam of the original seven while the remaining original beams remained unbroken under 214,000 applications of this load. The load was then increased to about 60%, when all but one broke at an average of about 40,000 loads. This would indicate the possibility that a large number of repetitions of a light load may have a beneficial effect on the transverse strength of plain concrete.

Two additional sets of beams have been broken, 12 beams in each set. In order to avoid the possibility of the effect of initial light loads, before the machine was started two beams cast at the same time were placed in the testing machine and modulus of rupture determined. The load on the wheels for the first additional set was then proportioned to approximately seventy per cent of the modulus of rupture. Under this load all of the new set of beams broke under repetitions varying from a few hundred to a few thousand applications.

An additional set of 12 beams is now being tested with a load on the wheels which will give a stress approximately equal to 60% of the modulus of rupture. This set of beams is carrying a considerably higher number of repetitions than was the case where beams were loaded 70% of modulus of rupture. They are, however, breaking under number of repetitions much less than might be expected during a year's time on a road slab carrying traffic of considerable intensity. From the behavior of the second and third sets of beams there is good reason to suppose that the percent of the ultimate load that may be applied indefinitely may be affected materially by the age of the beams when first subjected to repeated loads. The tests now under way, therefore, are all being made on beams 28 days old when placed in the machine. From the results so far obtained it would seem probable that plain concrete in transverse bending may be able to withstand an indefinite number of repeated loads provided the stress is something less than 60% of the modulus of rupture. We hope soon to be able to say what a safe value for this per cent should be. The fatigue machine is shown in the illustration on the front cover.

Position of Loads for Maximum Stresses

Fig. 6 indicates conditions which may apply along the edges of a pavement slab. Diagram A represents the deflection readings of an Ames dial placed at the edge of the pavement during the passage of a 4-ton wheel load along the edge of the slab as close to the dial as feasible. The dial in this case was placed at some distance from the nearest transverse crack. It is of interest to note the shape of the curve showing

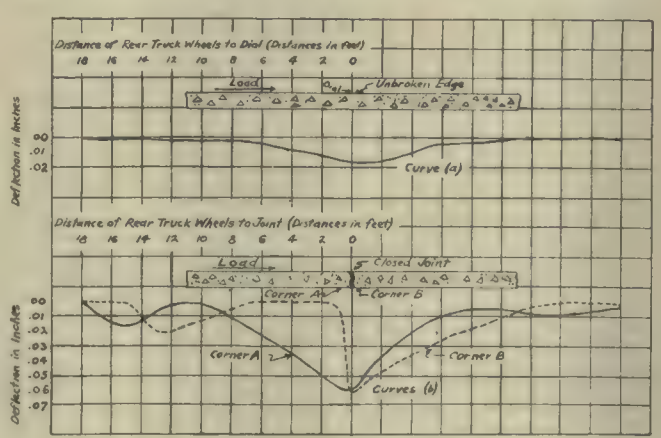


FIG. 6.—CURVES (A) AND (B)

the deflection of the edge at the dial as the wheel passed and the total amount of this deflection. Fig. 6(b) shows the curve of deflection when two dials were placed on the corner formed by a transverse crack. In this case the crack was very fine, the observations having been made during a period of high

summer temperature when the slab was expanded and apparently all cracks closed very tightly. Note that the total deflection is much greater than shown in (a), although it is apparent that the closed crack prevented each corner from acting independently. Curve (c) shows a similar condition in which, although the crack was open, short dowel bars passed across it. Note that the deflection is approximately the same as that which occurred at the closed crack. Curve (d) shows the very marked effect occasioned by an open crack or joint with no dowel bar or other means for causing both corners to act together. Deflections of the center of a slab under load were too small to be plotted to this scale. While deflections only are plot-

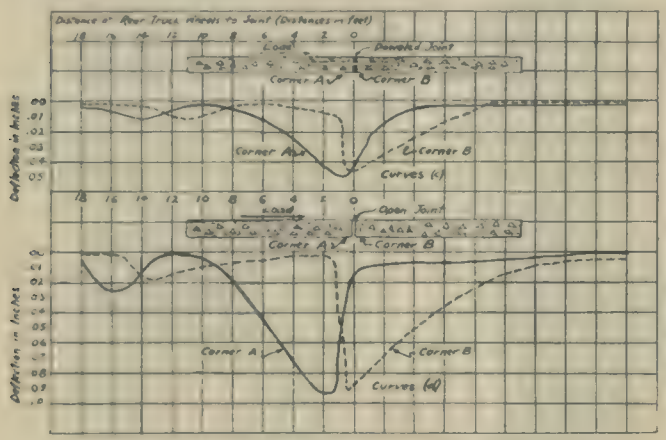


FIG. 6.—CURVES (C) AND (D)

ted in these diagrams, yet strain gauge measurements show the some proportionate results. As stresses are in proportion to strains the position of loads to produce maximum slab stresses are easily apparent from these diagrams. All of these deflections are plotted from observations on slabs of the same thickness and taken during the night when the edges of the pavement were not in contact with the subgrade.

The advantage of providing means for causing adjacent corners to act together in supporting concentrated loads is also unmistakably illustrated by Fig. 2. The readings from which these corners were plotted were taken on a corner formed by a construction joint entirely open to the subgrade except that short dowel bars were in place across the joint. The load was imposed upon the corner on which these deflections were taken. Note that during the first night while the dowel bars were in place the maximum deflection under load was only about 0.03 in. The dowel bars were cut at about 9 o'clock the next night with the result that the maximum deflection under load increased to about 0.08 in.

The Design of Rigid Pavements

It is of course fundamental that in order that any structure may rationally be designed the maximum loads to which it will be subjected must be known. The position and frequency of the application of the loads must also be known or assumed to be such as to produce the maximum destructive effect on the structure. It would also seem to be of prime importance that the actual impact factor of highway wheel loads on pavements constructed as smoothly as may be practical under modern methods should be determined.

Until exhaustive investigations can be made to determine the economic truck unit, we are faced with the problem of controlling maximum wheel loads by legislation based upon arbitrary judgment. The Illinois law provides for a maximum axle load of 16,000 lb. This may be assumed to correspond with an 8,000 lb. wheel load. As to the frequency of the passage of such wheel loads over pavement slabs, it is our observation that on trunk line roads in the near future great numbers of trucks, loaded to the limit prescribed by law, may be expected. Allowable stresses must also be fixed and the subgrade support duly considered.

In the light of what we believe to be conclusive evidence that an uncovered rigid slab may become warped by temperature effects so that it will, for from 8 to 12 hours out of every 24, be completely unsupported along the edges by even the best of subgrades, and considering the probability that at least on clay subgrades at certain seasons of the year the soil may have an exceedingly low supporting capacity, and further considering the fact that during the period of greater subgrade saturation which no doubt occurs immediately upon the thawing out of the ground in the spring when low temperatures prevail, the cracks are open to the maximum amount, it would seem that to resist local breaks it is necessary to design the corners of the pavement as unsupported cantilevers. Unbroken edges are far less susceptible to traffic breaks than corners, as is clearly illustrated by Figure 6.

It is the writer's firm belief that if the thickness of the pavement be designed to carry the maximum load at the corners in accordance with the formula

$$d = \sqrt{\frac{3W}{S}}$$

which formula covers conditions at unsupported right-angled corners, the remainder of the pavement will be well able to carry the same load without breaks which would damage its usefulness as a pavement surface.

The derivation of this formula is as follows:

Assume load W applied at corner

b=Moment arm to section A, B

Then if A, B, makes a 45° angle with the edge of the slab AB=2b M=Wb

S=allowable tensile stress

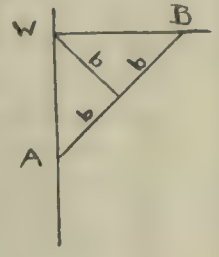
I=Movement of inertia of stressed section=$\frac{2bd^3}{12}$

C=$\frac{d}{2}$

Substituting these values

S=$\frac{Mc}{I}$ reduces to

S=$\frac{3W}{d^2}$ or d=$\sqrt{\frac{3W}{S}}$



If means could be found to make both corners act together by placing longitudinal shear bars along the edges of the pavement, or by some other means and the corner weakness thus be reduced by one-half, the design formula

$$d = \sqrt{\frac{1\frac{1}{2}W}{S}}$$

could be used with a reasonable degree of safety. In order that all possible corners might be taken care of, it is believed that the position of the longitudinal crack should be controlled by constructing a longitudinal joint and adjacent slabs held in close contact by transverse tie bars. The interior corners, being held in close contact along the longitudinal joint by the transverse tie bars, should be fully as safe as the edge corners. The shear bars along the edges should also be continuous in order to take care of corners formed by transverse cracks regardless of their position.

Fig. 7 shows the thickness of slab required if designed in accordance with the formulas heretofore given, assuming a safe working stress for 1:2:3½ concrete in tension of 200 lb. per square inch. The upper line is plotted from the formula

$$d = \sqrt{\frac{3W}{S}}$$

and the lower line the formula

$$d = \sqrt{\frac{1\frac{1}{2}W}{S}}$$

The result of our fatigue tests although not yet complete seems to indicate that a working stress higher than 200 lb. per square inch may be safe for concrete of the quality ordinarily used in road construction. The data so far obtained indicates that a single ¾ in. shear bar placed along each edge of the pavement may not be 100% efficient in making both corners act equally under a load applied to one corner only. This may be due to the use of a heavy coat of asphalt on the bar, which has been the practice up to date. The yielding of this more or less plastic coat may be the principal cause of this trouble. Experiments are under way to determine, if possible, more effective means of transmitting one-half of the load across the crack.

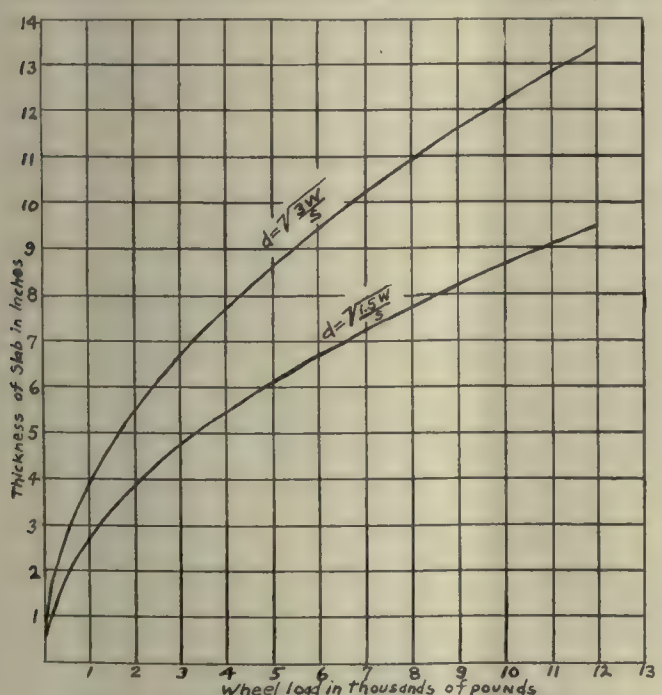


FIG. 7.—REQUIRED THICKNESS OF SLABS

The following tests bear out the value of the above formula for use in designing concrete slabs to resist corner breaks.

Example 1. On a corner formed by an open crack an 8,000 lb. load was applied repeatedly by means of a hydraulic jack. The slab was 6½ in. thick, 1:2:3½ mix, and about 1 year old. Fibre stress computed by the formula

$$S = \frac{3W}{d^2}$$

is 569 lb. per square inch. The corner broke under the 76th application of the load. The subgrade had been removed from under the slab after the 30th application.

Example 2. On a similar corner a 6,000 lb. load was applied on a 6½-in. slab of the same mix and age. Computed fibre stress 426 lb. per square inch. The 62nd load broke the slab. The subgrade was a sand loam and had not been disturbed. The corner broke in the day time when the subgrade support should have been at a maximum.

Example 3. An 8,000 lb. load was applied in the same way to a corner formed by a construction joint. Short ⅝-in. dowel bars were in place across the otherwise open joint. Slab thickness 4¼ in., mix 1.2:3½, age about 6 months. Fibre stress computed by the formula

$$S = \frac{1.5W}{d^2}$$

is 666 lb. per square inch. The corner broke at night under the 14th application of the load.

By means of the same outfit the behavior of several hundred other corners subjected to less than breaking loads have been observed. Using strain gauge readings as a measure of stresses we have been forced to the conclusion that under average conditions material subgrade support to corners does not exist.

The Effect of Intensity of Traffic

From the above discussion, it is evident that aside from traffic accommodation considerations, roadways of a width such that under normal traffic conditions frequent turning off and on the slab by heavy trucks may be avoided, are much to be desired.

The fatigue experiments above referred to indicate clearly that the life of a concrete slab may be long or short depending upon the frequency of the passage of loads great enough to stress the concrete up to fity per cent or more of its modulus of rupture. For example, our fatigue tests show that a few thousand repetitions of loads sufficient to stress the concrete up to sixty per cent of its modulus of rupture cause failure. If on a given road about 5,000 loads sufficient to stress the concrete to this figure occur during the first month's use, the slab in all probability would fail

the first month. If the same number of equal weight loads should not occur for several years it is entirely possible that the life of the pavement might be indefinite, as undoubtedly the modulus of rupture would have materially increased.

In the light of the investigations showing the marked warping of concrete and monolithic brick pavements, due to temperature changes, it is the writer's judgment that such slabs should be designed for a corner strength sufficient to reduce the fibre stress to a safe limit regardless of the character of the subgrade. It is no doubt true that the higher the supporting power of the subgrade, the lower will be the fibre stress of the slab under day time applications of load; nevertheless the warping of the edges and corners upward at night is so great that the best of subgrades would be of little value in reducing the slab stress under night applications of maximum loads. Good subgrades may therefore materially prolong the life of a pavement by reducing the frequency of the occurrence of load breaks would be merely a matter of the intensity of traffic at night and during periods when the pavement is least supported by the subgrade unless the slab is designed for such critical conditions.

Coordination of Highway Interests*

By WILLIAM ORD†

Cooperation is a word that has grown to have a very large meaning in all walks of life in recent years. Formerly "might was right," but now "the greatest good for the greatest number" is the foundation of most successful institutions. This is secured by cooperation, by all interests working together for a common benefit; and is in contrast to the principle of "Every man for himself, and the devil take the hindmost."

Wherever cooperation has been intelligently and faithfully tried, wherever an immediate, selfish, interest has given way to a larger, more common interest, it has been proven good. It takes time for the benefits of cooperation to become fully manifest, but in the long run it always pays. This has proven true among nations, among states, and other smaller communities. It has proven true also in social affairs and in, what is more to our point, business.

It is not necessary to discuss at length the merits of cooperation as a general principle. Books have been written about it, telling how cooperation has worked. It is necessary for us road builders all to get together to see how we may use it for the benefit of our industry as a whole, as well as for the benefit of our members individually.

If we are to study this proposition we may start by asking three questions:

1. Who are definitely the parties we expect to cooperate?

2. What benefits are we to seek, or may we expect, from proper cooperation?

3. How are we going to promote cooperation, not only to get over the idea, but to get constructive action?

Let me briefly try to outline the answers as I see them now, after a very limited amount of personal observation. There are, I believe, ten parties, or interests, who all have more or less to do directly with every road that is built. They are—

1. The people as a whole, including the taxpayers who buy the roads, and the vehicle owners who use them.

2. The legislators who make the laws governing the financing, construction, and use of the roads.

3. The engineers of our highway departments who locate and design the roads, who superintend their construction, and later are charged with their maintenance.

4. The contractors, who perform the actual construction work.

5. The manufacturers and producers who supply the necessary materials which may not be produced locally by the contractor.

6. The other manufacturers, who furnish the tools and machinery.

7. The railroads, who provide the transportation of materials, plant, and men.

8. The bankers, who handle the moneys passing among all the other parties.

9. The bonding companies.

10. Labor.

The trade press is, of course, to be considered a factor in the industry. The work it does is highly important in bringing all the other ten parties closer together, and in the analyses it makes of the problems of each. It is not, however, directly responsible for any part in the construction of any one road, and it is proper, I believe, to omit it from the list given.

Our industry, at least of its present magnitude, is so new that all its problems have been difficult to classify, to say nothing of their difficulty of solution. The war served to complicate many issues that would have been easy to analyze in normal times. It may be said, however, that each of the ten parties mentioned above has made great and important progress in its own particular branch of the business. There has been a development of uniformity in road laws. Designs and specifications are clearly becoming more standard

(Continued on Page 162)

*Paper presented at Nineteenth Annual Convention of the American Road Builders' Association.

†Manager, Paving Dept., Lakewood Engineering Co.

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

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Articles by road builders are solicited. They should be short and, if possible, accompanied by photographs. Those accepted will be paid for at current rates.

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EXPERIMENTAL WORK IN ILLINOIS

Elsewhere in this issue is printed an article by Clifford Older, Chief Highway Engineer of Illinois, describing the research work done on the Bates Experimental Road in that state. From these experiments Mr. Older draws the conclusion that concrete slabs "should be designed for a corner strength sufficient to reduce the fibre stress to a safe limit regardless of the character of the subgrade. It is no doubt true that the higher the supporting power of the subgrade, the lower will be the fibre stress of the slab under day time application of the load; nevertheless the warping of the edges and corners upward at night is so great that the best subgrades would be of little value in reducing the slab stress under night applications of maximum loads."

An interesting point in connection with the experimental work is the conclusion of Mr. Older that "the fatigue experiments indicate clearly that the life of a concrete slab may be long or short, depending upon the frequency of the passage of loads great enough to stress the concrete up to fifty per cent or more of its modulus of rupture. For example, our fatigue tests show that a few thousand repetitions of loads sufficient to stress the concrete to this figure occur during the first month's use, the slab in all probability would fail the first month. If the same number of equal weight loads should not occur for several years, it is entirely possible that the life of the pavement might be indefinite, as undoubtedly the modulus of rupture would have materially increased."

HIGHWAY SAFETY INSTRUCTION

Highway fatalities increase each year, the most rapid rate of increase being the cities, where there is congestion of vehicular and pedestrian traffic. Some cities, notably, Detroit, Mich., are now giving instruction in the public schools to educate the children to observe the rules of safety on the city streets. It is hoped that the time will soon come when all the important cities will include this instruction in their public schools.

"I think that if it is possible to educate chickens to caution, it ought to be possible to educate human beings," said George M. Graham at a recent dinner of the National Automobile Chamber of Commerce. "I notice the chicken is becoming very cautious. She is learning something, and I say 'she' advisedly, for I notice that the chicken that gets run over is always a hen.

"The rooster stands in dignified state on the side of the road and grins tolerantly, while the flurried hen tries to cross back and forth in front of the car five times. But some impulse of precaution born of maternal admonition comes to the mind of the hen today and says, 'It is wisdom to stay on this side and let it go by.'

"Now if hens, with their limited modicum of brains, can be trained that far in safety, why not also children? It is simply a case of carrying the message to them."

1922 WILL BE A BIG YEAR

During the years 1919, 1920 and 1921 a considerable amount of road construction was done in this country, yet during these years many reactions due to the war were in operation, such as the shortage of labor, inadequate transportation facilities and unfavorable bond market. Conditions are now approaching normalcy and undoubtedly 1922 will be a banner road building year. Labor is plentiful, material costs have receded, Congress has appropriated federal aid funds for the current year, many state and county bond issues have been voted in addition to those voted but not yet expended, and finally, it is now possible to market road bonds. Surely the outlook for the road builder has never been brighter.

ALABAMA PASSES $25,000,000 BOND ISSUE

The State of Alabama has passed a $25,000,000 road bond issue for the construction of a state highway system, as noted in last week's issue. In 1920 an amendment to the state constitution was passed by a referendum vote authorizing the issuance of $25,000,000 of road bonds. However, because of some legal technicality, the supreme court on Feb. 3 of last year declared the measure unconstitutional. But the desire of the people of Alabama for modern roads was not to be set aside, as shown by the recent election, the vote being 25 to 1 for the issuance of the bonds.

THE COORDINATION OF HIGHWAY INTERESTS

(Continued from Page 160.)

ized. Contractors have so improved their methods that their individual outputs per annum have greatly increased. and considerable has been accomplished towards reducing costs and improving quality.

Means of using satisfactorily materials formerly considered of inferior quality are being found by the material producers collaborating with the engineers. Machinery has been revolutionized; and we have found improvement in matters of finance, bonds, transportation, and in the training, working, and care of labor. All the progress that has been made is, however, probably infinitely small in measure when compared with what we still have to do.

It is to be noted that practically all branches of our industry have been organized for cooperation among the members of each branch. The people have their good roads associations, automobile clubs, and chambers of commerce with good road committees. The thinking of our lawmakers in being headed up at Washington and a national view of good road subjects is more generally being taken there. Our highway engineers, contractors, machinery and material people, and also the railroads, banks, and bonding houses, are all associated with others of their kind. Finally, labor has its unions.

The work these associations have done has been of remarkable benefit to the industry as well as to the members of those associations. There is no need to go into detail. We all understand to some extent how they are functioning and the progress they are making. We know, for instance, how much the brick, cement, and asphalt associations have helped solve hard surface problems by their investigations; how the Associated General Contractors have stabilized contracting by cooperating with engineers to improve contracts and how the auto clubs have helped to broaden the demand for good roads.

It is more significant, however, to note how the various associations are beginning to work together and how they are beginning to be interested more and more in each other's problems. Last month there was a Highway Construction Conference in Harrisburg, Pa., in conjunction with the annual meeting of the Associated Pennsylvania Highway Contractors. Persons from all branches of the industry were invited and many of them gave talks. Lower freight rates on materials, costs of bonds, relations of contractors with bankers, the cement market, and many other such subjects, each affecting several different interests, and demanding cooperation, were discussed. A resolution was passed urging a greater degree of standardization in machinery, and suggesting conferences between the contractors and the machinery manufacturers. The spirit of cooperation dominated the whole meeting.

A very pretty illustration of what cooperation can accomplish was given a year or two ago when it was pointed out, first, I believe, by Mr. MacDonald of the Bureau of Public Roads, that in the winter time the railroads have an excess of open top cars and a shortage of them in the summer. Everybody interested took hold of this idea with the result that the highway engineers are awarding their contracts earlier, so the contractor can arrange for winter shipping and storage of materials. Laws were passed in many states providing for partial payments on materials so stored. The railroads were benefited. The season of the sand, gravel and stone companies was lengthened, the contractor is able to do more work per annum, more work is assured to labor. In fact it seems that this one action of awarding contracts early has affected our whole industry and all the ten interests in it.

We have a very practical demonstration this week, in this most successful road show in history, of how many of the road interests may be drawn together for a common good. We have also a horrible example of what may happen when things are not planned with the interests of all in mind. The exhibits in the Coliseum are brought here at a very large expense. The contractors are perhaps the ones to be most benefited by viewing them. And yet, we find the Associated General Contractors holding a convention of their own in Cleveland on exactly the same dates as the road show in Chicago. There surely can be no reason for it except lack of cooperation. It is unthinkable that any contractor who can attend that convention in Cleveland would not enjoy and be benefited by a day or two looking over the many new things on display here.

We have had many other very interesting examples of cooperation between our branches in the past. The results have been gratifying and it has been most thoroughly demonstrated that willingness to cooperate exists everywhere. Cooperation has, however, been a sort of hit or miss proposition. Issues have been met not only as they have arisen. Very little has been done to plan cooperation of all parties. It is perhaps because our industry is so large in volume and spread out so all over the country and has so many ramifications.

It has been difficult, if not impossible, for any one to grasp the entire problem. To me it is clearly indicated the work of cooperation must be planned by a committee of an association such as the American Road Builders' Association. This is, indeed, the only body large enough to attempt the work. It is the only national association still functioning, although there have been others come and go. This is really an association of associations, a federation, if you please, with a membership comprising all road building interests. Is there not an opportunity for us to do some real constructive work? Is there not a responsibility that must not be shirked?

Just how our association may be made to function for larger cooperation is a question for discussion.

Next year I understand we are to have a salaried secretary, who will devote all his time and best thinking to affairs of the association. That will be one step in the right direction. The work is vast, however, and the opportunity so large that I believe an able general manager with several assistants are needed. One assistant could look after increasing the membership to many times what it is now. Another could make this annual convention and exhibition his principal concern. Then why not begin to collect a library that would be the best on road subjects in the world? Statistics of interest to the members should be collected by the association. Perhaps we should have a committee on cooperation. The committee could analyze issues and assuredly be able to recommend cooperative action. The manager and his assistants should of course work with the committee to start the action.

Regardless, however, of what the association may be able to do, it remains for the members to cooperate among themselves to a much greater extent than they have done in the past. Let us study each other's problems, and especially the problems of those with whom each of us come most frequently in contact. Every single member of any of the ten interests is as justly entitled to consideration as you are yourself. He represents one-tenth of the list of active partners in building roads and is just as necessary to the industry as the representatives of any other interests.

In closing, let me state the "Law of Equal Reaction," which Babson, our foremost industrial statistician, has defined thus: "Every act of ours reacts to our advantage or disadvantage, according to whether it helps or harms all parties affected. This means that our future prosperity depends on the amount and quality of service we render. We get what we give, and prosper as we serve."

MASSACHUSETTS WOULD RAISE MOTOR FEES

Motor car owners in Massachusetts are threatened with greatly increased registration fees. The new bills introduced in the State Legislature provide for increases ranging from 50 per cent on small cars to 340 per cent on some of the larger veicles. On almost everything, except the smallest cars and the largest trucks, the increase is approximately 100 per cent. The commissioner of Public Works is asking for this increase in order that his department may have a much larger sum of money to expend upon road work.

It has been figured that Massachusetts motorists this year will pay in about $6,600,000. This money, taken with the Federal Aid allowance of Massachusetts and the amounts received from cities and towns in connection with the co-operative work in highway construction, will, it is estimated, give the department practically $10,000,000 with which to work this year. Motorists feel that this is a sufficient sum to keep the roads in good shape and to extend them a reasonable amount.

EIGHTEEN-FOOT BRIDGES THE RULE ON FEDERAL AID ROADS

Few highway bridges with a width of roadway less than 18 ft. are now being constructed on improved roads, according to engineers of the Bureau of Public Roads of the United States Department of Agriculture. In the past some of 12 ft. and a good many of 16-ft. width have been constructed in an effort to economize but it has proved short sighted economy. Only one line of traffic can pass over a 12-ft. roadway and 16-ft. of width will not accommodate two lines in safety. Many of the states such as Pennsylvania, New Jersey, Ohio, and Massachusetts have found it advisable in replacing old bridges on important roads to make them wide enough to accommodate three and four lines of traffic.

FOREIGN ENGINEERS INSPECT AMERICAN ROAD CONSTRUCTION

Foreign countries, particularly those of South America and Japan and China, are much interested in American methods of road construction.

In recent months the Bureau of Public Roads of the United States Department of Agriculture has been visited by several Japanese and Chinese engineers sent to this country to study the operation of the Federal and State highway organizations and to inspect actual construction.

According to one of the Japanese visitors, his country has recently made its first appropriation for modern highway construction, an amount that would not be considered large by some of our States, but it is thought that the movement will grow rapidly when the people can see the benefits of the roads to be constructed with the present appropriation.

In response to the interest in our roads shown by the South American Republics that the Pan American Union recently issued an educational bulletin on American roads, printed in Spanish and Portuguese, describing American practice, and illustrated by photographs collected by the Bureau of Public Roads.

WIDER HIGHWAY TENDENCY SHOWN IN ROAD BUILDING

Of 6,500 mi. of completed Federal aid road for which statistics have been collected by the Bureau of Public Roads, United States Department of Agriculture, one-half has been constructed of 16 and 18 ft. width, 25 per cent of a greater width, and 25 per cent of a less width. As would be expected the wider roads have been constructed largely in the more populous states, although some of the less populous states are building wider roads for the main highways. There is a general tendency, it is said, to build wider roads to meet the needs of the constantly increasing traffic, as shown by the 25 per cent of the mileage over 18 ft. in width, 7 per cent being 24 ft. or wider.

MEETINGS

Calendar of Coming Meetings

June 4-6—American Association of Engineers—Annual convention, Salt Lake City, Utah. Secretary, C. E. Drayer, 63 E. Adams St., Chicago, Ill.

June 26-July 1—American Society for Testing Materials—Twenty-fifth annual meeting, Atlantic City, N. J. Secretary, C. L. Warwick, Engineers' Club Bldg., Philadephia, Pa.

UNUSUAL DRAINAGE PROBLEM SOLVED

An unusual drainage problem on Federal Aid Project 120 in Ravalli County, Montana, is being solved by an interesting type of construction. Briefly, the conditions are as follows: For more than a mile of the project just out of Stevensville an 18 in. layer of gumbo covers a stratum of gravel under which is a layer of impervious material. The general slope of these strata is toward the Bitter Root Rivers about a mile distant. In the spring of the year when the snow is melting in the mountains the water sweeping through the gravel layer gains a hydrostatic pressure which forces it through the thin places of the earth road surface making it almost impassable.

To overcome this serious condition it was found impracticable because of right of way limitations to construct a side ditch of sufficient depth to intercept and carry off this surplus water. The plan finally adopted consisted of laying a 7 in. layer of field stones on the existing road over which a 3 in. layer of pit run gravel was placed. On this an 18 ft. feather edge gravel wearing surface will be placed. In effect a French drain has been constructed and all indications are that the former bad conditions have been economically overcome.

MAKES AUTOMATIC TESTS OF ROAD BUILDING MATERIALS

An experiment to determine just how hard rock or gravel must be in order to be satisfactory for use in building concrete roads is being carried on by the Bureau of Public Roads at the Arlington Experimental Farms of the United States Department of Agriculture. About 60 sections of experimental road are being constructed, in which practically every variety of stone, gravel, and sand will be used. These sections will then be traveled over thousands of times by a machine automatically operated and which has the same effect on the pavement as a motor truck. This will continue until the wearing properties of all the sections are determined. The bureau believes that the results of these tests will show that many local materials heretofore deemed unsuitable may be used safely in building concrete roads, thereby saving the cost of importing stone, gravel, or sand from a distance.

POLICE PATROL CONNECTICUT ROADS

A comprehensive system of patrols to cover the main highways of Connecticut will soon be put into operation by the State Police Department. In the height of the motoring season about three thousand miles of Connecticut highways will be patrolled by the state police force. It is the intention of Superintendent Hurley of the state police to do everything in the power of the department to make travel over Connecticut highways the safest in New England.

The coming spring and the call of the road brings out an ever increasing number of applicants for operators' licenses. The large number of non-residents who choose Connecticut resorts at the shore and in the country for their summer homes also swell the total of those operating automobiles under Connecticut licenses.

FILM SHOWS USE OF BRICK IN ROADS

The transformation of clay into a durable, hard surfaced, vitrified brick pavement, through modern methods of manufacture and road building, is visualized in a new United States Department of Agriculture one-reel film, "Bricks—From Clay to Pavement."

Scenes portray the digging of the shale or clay from its native bed; mixing, forming, burning and various processes in the manufacture of the brick; preparation of the road base; laying, rolling, filling and other operations with views of the completed road open for traffic. The sand-cushion, monolithic, and semi-monolithic types of brick-road construction are included.

The film was produced under the direction of the Bureau of Public Roads and is designed to instruct in approved road building practices. Copies may be purchased at the production cost of approximately $37 or will be loaned, free, for short periods.

PERSONAL MENTION

George Mattis has resigned as city engineer of Oakland, Cal.

George E. Johnson has resigned as state engineer of Nebraska, effective at the end of the present year.

R. C. Brown has ben appointed acting state highway engineer of South Carolina.

A. H. Chambers has resigned as city engineer of Logan, Utah.

Fred W. Thomas has been appointed city engineer of Logan, Utah.

GOOD ROADS

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Volume LXII. March 22, 1922 Number 12

TABLE OF CONTENTS

Relation of Motor Truck Overloading to Road Construction and Maintenance. By J. G. McKay . . 165

Railway Department Formed by Wisconsin Highway Commission 170

Will Test Road Until It Fails 170

Snow Removal on Country Highways. By C. J. Bennett 172

Motor Vehicles Increase 175

Good Roads and the Farmer. By K. L. Hatch . . 176

More Roads Are Necessary Says a Nebraska Farmer 177

Road Program of Indiana 177

New DuPont Dynamite 178

EDITORIALS:

Good Roads and the Farmer 171

Snow Removal on Rural Highways 171

Unusual Road Tests in Illinois 171

MEETINGS:

Calendar 178

Ontario Good Roads Association 178

PERSONAL MENTION 178

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GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

WITH WHICH IS INCORPORATED

THE HIGHWAY CONTRACTOR AND ROAD BUILDER

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Relation of Motor Truck Overloading to Road Construction and Maintenance*

By J. G. McKAY†

Highway design must necessarily be based upon traffic, and the behavior of the various details of design observed under different ranges and types of traffic. Highway transportation is in a condition of flux. An immense growth may be anticipated in the next decade. Our rapidly growing mileage of completed highways, with the prospect of continuous increase each year of construction programs emphasize the urgent need of road information upon which to base sound, economical road building policies, that we may avoid the mistakes and disasters of unwise financial methods and unsound construction policies. The solution of engineering problems of design, maintenance and the like, depends largely upon the character of the traffic, its speed, and the unit loads the highway must carry. The true purpose of an improved highway is a high degree of transportation service at the least possible cost to the public and road user. Clearly a traffic census is not a panacea, but I insist that without a knowledge of the actual traffic, speed, type, and weight, of a given area, we are working in the dark. The actual traffic in terms of volume, density, speed and unit weights, must be correlated with laboratory and experimental impact tests as a guide to rational design. Independently each type of research is valuable, but the true worth of both cannot be realized until combined—in other words, interpreting the results of laboratory experiment in terms of vehicles on the highway.

Our state and national investment in highway systems is constantly increasing. The investment in motor vehicles and the automotive industry is constantly growing steadily. A careful analysis must be made of the chief traffic elements responsible for increased construction and maintenance costs before the enactment of legislation which may, while protecting the highway, prove injurious to the growth of a highway transport service, and detrimental to the automotive industry. We must be certain of our facts before we limit the traffic which may pass over any given highway. The limitation of wheel and gross loads must be based on definite information. The rapid destruction or ruin of gravel or macadam, and even concrete construction under heavy traffic does not necessarily mean that the construction of more durable pavement types is essential. It is conceivable that the heavy freighting vehicle is not an economic unit load, and that ultimately a smaller unit will become the maximum.

In making comparisons of the economies of the different methods of freight movement we are prone to make comparisons on the basis of operating costs alone. The true haulage cost must be based not only upon the cost of operation of the vehicle, but also a portion of the cost of building and maintaining a highway for the movement of vehicles, and must be included as a cost charge. Naturally this cost increases rapidly as the unit loads increase. Saving in transport costs may occur when heavy vehicles operate, reducing the freight costs by a few cents per ton mile. On the other hand a decided economic and social loss arises when new roads must be built, or maintenance costs are excessive due to the utilization of the highway by heavy vehicles. The savings in operating costs of a few cents per ton mile are more than offset by the heavy construction and maintenance charge. It is not alone a question of cost, but the road is out of service which is even more serious.

It may be that an increase of the tire width per capacity of trucks to carry the freight load without destruction of the pavement is the solution. It is possible that the tire equipment should be capable of carrying the entire load, as suggested by Mr. Otto Armleder, manufacturer of Armleder trucks. This would solve the problem of overloading on the rear axle, but would not reach the problem of the total unit weight on the pavement, or overloading on the front axle. A study of the comparative economies of

*Paper presented at Nineteenth Annual Convention of the American Road Builders' Association.

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three, five and seven ton trucks with regard to highway construction and maintenance, vehicle operation costs, and service time, would settle this controversial point and determine the maximum economical load unit.

It does not appear that the use of pneumatic tires is a possible solution, limited to use on small capacity trucks, and prohibitive in cost.

Today we see a strong tendency in the direction of restrictive legislation limiting the total loads which may pass over our highways and bridges. The classification of a highway system which limits the gross weight to twelve and a half tons on a very small percentage of the roads of a state, and to seven and one-half tons on the balance of the state system, definitely limits the manufacturer of trucks to a limited area for the sale of heavy vehicles. It is to his own best interests to cooperate in the solving of this difficult problem in order that his market may not be restricted beyond reasonable limits. The establishment of weight limits per inch of tire width must be based on conclusive evidence and research.

The manufacturer of trucks cannot afford to design and market vehicles which unduly increase the cost of construction and maintenance of our highways. The highway engineer cannot afford to build roads that will cripple or limit unduly the hauling capacity of trucks. There is a joint enterprise, a movement of the maximum traffic at a minimum cost, and upon its successful solution rests the welfare of both the public and the vehicle manufacturer.

It is an open question whether or not the ultimate sphere of motor truck operation is to be competitive with or supplementary to our existing transport system. The consideration of this problem carries with it far reaching consequences, beyond the mere comparison of the cost of movement of freight by one or the other type of carrier. The movement of freight is by nature monopolistic, and does not permit of true competition. Either one or the other type of transport will occupy the field. The junking of our railroad investment would involve the destruction of property rights representing approximately one-twenty-fifth of our national wealth. We must consider the relative difference in the investment, comparing a large railroad system, with strict governmental regulation of rates and service, with fleets of motor vehicles in which the investment of the owner is small, with an absence of rate regulation or guarantee of service. The railroad investment is permanent and cannot move to an alternative field, it must operate or become a loss. The commercial vehicle operator, however, may move to alternative fields when profits fail. This naturally would endanger the guarantee of freight service which is more fundamental a question than cost. It is difficult to conceive of the movement of heavy freight of low value by truck transport. The cost of moving such products as coal and iron, pratically limits the commercial truck field to high value and low bulk goods. Can the railroads operate profitably moving the low value and large bulk commodity goods on the short haul, while the profitable business is absorbed by the motor vehicles? Any comparison of the two types of transport with a view of selection of the more economical type involves a comparison of costs. In such an analysis we must not forget that the cost of construction and maintenance of the road bed in both cases, is a part of the charge which must be made against the freight moved. A proper share of construction costs and maintenance costs of the highway must be paid by the truck operator, before a real comparison of rail and truck rates can be made.

A clear analysis of all the factors involved must be made before we can determine whether the field truck operation as a carrier is to be the competitive or supplementary to existing transport systems.

Unprejudiced research is fundamental in the attempt to solve these many many difficult highway problems. Supply definite information to the highway engineer with the assurance that the type and weight of traffic will not change over night, and he will build safely and permanently roads able to carry the traffic at a cost not exceeding the service value of the highway to the community. The vehicle manufacturer in all fairness is entitled to know the facts upon which he must design and build trucks which will meet the requireemnts of a constantly increasing highway legislation.

In approaching an analysis of some of the factors involved in highway construction and maintenance, and motor vehicle movement, a clear picture of the traffic passing over a given highway is essential to a thorough understanding of the type of construction necessary for traffic of a given type, giving at the same time a definite idea of the regularity of motor vehicle movement, density, weights and produce.

A traffic census may be defined as "a complete summation of traffic passing over the highways of a given area during a definite period of time."

Every traffic census has certain limitations and a traffic census based on the following plan has the fol lowing limitations:

1. A certain portion of the traffic over newly completed roads consists of "attracted" traffic from other routes and does not represent the true traffic which will ultimately pass over the particular highway observed. Allowance must be made for a re-distribution of traffic when parallel highways of the complete system are constructed.

2. We cannot expect that a summation of vehicular movement will accurately portray future traffic. To obtain a picture of future traffic the census must be taken at given intervals over a period of years to determine the percentage increase of each vehicle type. The potential traffic of a given area to supplement the actual traffic census may be obtained by a survey of

the agricultural and industrial growth of the community.

3. Only in a general way will the census data answer the question of the influence of various types of traffic on the highway without maintenance studios of the same road, correlated with impact studies. To be able to interpret correctly the weight and volume data, accurate maintenance cost studies are essential. It is advisable in the selection of traffic census stations to place them on highways on which maintenance costs of the various types of pavement are kept.

4. The tonnage volume, and weight per capacity of various vehicles will be of more value when combined with impact studies showing the effect on different types of pavements by impact tests. Being given the result of impact studies on the several road types, produced by the different vehicles, as shown by the census, the construction engineer can be assured of the type of highway he must build to carry the traffic. This will prevent over or under-construction with the economic wastage occuring in either case.

In the past, traffic censuses have been taken by state highway departments largely for the purpose of determining the number of vehicles, passengers and types to indicate numerical movement. Generally such survey occurred during density of movement and for short periods of time. In a few cases the period of the survey was longer, while in one case actual weights were recorded.

In the belief that the expense of taking traffic census should produce more than surface results, and that the importance of the problems involved call for definite information, the following outline of traffic census is evolved.

The main purposes of a traffic census may be summarized as follows:

1. An aid in determining the economic value of a highway. Three principal factors enter into the valuation of a highway improvement. The increase in land values, highway service value in terms of passenger and freight ton miles, and the general value to a community. The only method of obtaining passenger and freight ton miles is by means of a traffic census for a definite period translated into yearly traffic.

2. Classification of vehicular traffic. A classification of traffic of the several types is useful in formulating traffic regulations, and to some extent in determining the percentage source of revenue from highway users in accordance with their actual use of the highway.

3. To determine gross truck weights and overloading per truck capacity. Weight and speed are guides to design, pavement selection, limitations of grade and alignment. The facts as to overloading per capacity can only be determined by a knowledge of front and rear axle distribution of weight in terms of loads per inch of tire width. It is not merely a problem of loads beyond a given maximum, but the real difficulty lies in overlooking beyond truck capacity.

4. Distribution of construction and maintenance funds. To distribute maintenance and construction funds in a fair proportion to traffic, we must know the volume and type of traffic on the different highways. The greater the volume of traffic, logically the greater the per cent of construction and maintenance funds allocated.

5. To determine traffic density and truck body widths. The peak of traffic hourly, daily and during the season is essential. Peak density and speed influence width of pavement and determines the maximum width necessary to carry the peak load. A direct ratio exists between vehicle body widths and pavement width. Pavement width increases with the increased speed movement of the vehicle, particularly when the load is heavy.

Seasonal and yearly traffic volume and density enable a prediction in a general way of future traffic.

6. To determine the vehicular movement of freight. Information as to regular and irregular trucking lines throws light on the proportion of regular freight movement. This is particularly valuable in the industrial states of the east and northeast. The average length of haul of commercial freighting indicates the field of competition of the truck and the railroad, whether the short or long haul. The type, volume and value of commodities moved indicate the commodity competition and the per cent of high value and small bulk freight moved as compared with low value and large bulk freight. The average delivery time indicates the rapidity of movement of commercial freight service.

Information relative to truck operating costs and freight rates does not properly lie in the field of a traffic census, but must be made through independent studies.

7. Average speed of vehicles. This data must necessarily be obtained at the same time the census is recorded to check each vehicle observed in the speed test with the data obtained at the census station. The recording of the license number in each case permits the determination of capacity and weight. This information is useful in the formulation of speed regulations and their enforcement.

8. Bases of the formulation of traffic regulations and their enforcement. The information as to weight, overloading, tire condition, body widths and speed not only afford a reasonable basis of traffic regulation, but is the data upon which enforcement depends.

With those purposes in mind a comprehensive study of highway traffic was conducted in the State of Connecticut during August and October of 1921 by the Connecticut Highway Department in cooperation with the Bureau of Public Roads. This survey consisted of two traffic censuses conducted on two of the principal highways of Connecticut according to a plan I had outlined as the basis of a model traffic census, and was put into operation by Highway Commissioner Bennett of the State of Connecticut. Each survey covered a

period of two weeks, and included two night surveys to determine the percent of night movement. Scales were installed by the Connecticut Highway Department on the road side by means of which the actual weights of trucks were obtained.

Truck Overloading

As I have already suggested, the production of highways and of vehicles which utilize our highways represent two industries in which the yearly investment exceeds by far any other two industries in the United States. The past few years have witnessed a tremendous growth of new highway construction and the volume and types of vehicles using our roads. The interests of the highway engineer and the producer of motor vehicles are largely the same. The one to construct and maintain highways which will carry a maximum of traffic of economical weight units at a minimum cost. The automotive manufacturer to produce vehicles which will move the traffic at a minimum cost and with the least damage to the highway. We cannot afford the waste of building roads to carry all types of traffic and unlimited loads, nor can we fit the vehicle to all types of highways. It is a combination of both, the building of suitable and satisfactory roads, and motor vehicles of the proper construction and weight. This is a joint industry of the road maker and the road user with a common object, the production of transportation at a minimum cost.

Naturally in any industry whose growth has been as rapid as the development of our highway system, abuses arise. Difficult problems develop upon whose successful solution rests the continued support of public approval. We have at present in the highway industry, many unsolved problems of highway economics and engineering which require immediate consideration. Intricate problems of finance, transportation, valuation, construction and maintenance, are a constant challenge to research in the field of high economics. This is a major field of operation and calls for the mutual cooperation of all people interested in seeing the creation of permanent and continually usable roads at a minimum of expense.

One of the most serious difficulties confronting the highway engineer today is the construction of roads which will remain in existence long enough to justify the investment, and at the same time withstand the hammering of the steadily increasing volume of weight to which the pavement and subgrade are subjected. This presents a two-fold problem. First the problem of excessive loads above a given maximum weight which results in the premature destruction of the highway. In 1920 only 1% of the motor trucks manufactured were over 5 tons capacity. The California Highway Commission in a recent statement says: "As the ratio of use must be in close proportion to the ratio of production, it follows that only about 3% of the vehicles using the California State Highways are the so-called heavy duty type. Highway construction, like any other governmental activity is based on public necessity and this necessity should be met reasonably when highways are built, adequate to sustain 90% of the traffic. This percentage would include all motor vehicles including the two ton capacity. Assuming $30,000 per mile as adequate to sustain 90% of the vehicular traffic of the State and $50,000 per mile to construct a highway which will sustain the weight required by 10% of heavy duty trucks, should the general tax payer be required to invest an additional 66% in road construction for the primary benefit of this particular call of heavy vehicles?"

We must fully recognize the necessity of automotive transportation, and the need for construction which will carry modern traffic, but first we must determine the economic load units, and second eliminate overloading. The weight of single units and speed are the two essential points of difficulty. The greater the speed of heavy loads the more damage to the highway. The ratio of damage to the road with an increase in speed is altogether out of proportion to the economies gained by faster movement.

The fact that pneumatic tires are found on the smaller capacity vehicles should seem to eliminate the use of the pneumatic tire as a solution. Reduction of speed, elimination of overloads, and restriction of gross tonnage and an increase in depth and width of solid tire equipment will reduce highway damage.

The majority of heavy movement occurs on our trunk highways usually between industrial centers. There is, however, some movement of heavy loads on our secondary highways and generally the result is ultimately the destruction of the highways. Under adverse weather conditions, a single trip of a heavy load over roads built to carry light traffic results in its destruction. An example of what may occur was shown during the "Ship-by-truck" week a little over a year ago when an attempt was made all over the country to relieve the railroad freight congestion. The destruction of highways unable to maintain heavy traffic more than offset by many millions of dollars the economies which resulted by relieving the railroads of their freight congestion.

It is not contemplated that we will ever construct our secondary highways to carry the maximum loads imposed on our primary roads. To prevent the destruction of our secondary systems by heavy trucking vehicles and loads, a classification of highways necessary limiting the maximum weight of vehicles moving over each road classification. The Wisconsin Highway Commission recently put into operation a classification of highways with the object of regulating track weights on its trunk highways and secondary roads. Class A roads limit the loads to 12 tons, while class B roads limit the load to 7½ tons. The majority of Wisconsin highways, primary and secondary at the present time fall under class B. Class A roads consist of the more durable construction types, while Class B consists of

the less durable types. Strict supervision of the weights of vehicles using the highway, and severe penalties for violation of such a classification are essential in order to compel obedience to the law regulating the maximum and capacity weights which may move over each class of highways.

In Maryland all loads in excess of 10 tons, vehicle and load, are forced to unload excess weight at once, leaving it on the highway. Ohio orders overloaded trucks off the road. Gross weight limits in the various states range from 6¼ tons maximum in Vermont to 15 tons maximum in California, Michigan and New Jersey. About one-half of the states specify a maximum load per inch of tire width ranging from 500 lbs. per inch in Idaho, Oregon and Texas, to 800 lb. per inch in Connecticut, Illinois, Iowa, New Jersey, New York, Pennsylvania, Washington, Wisconsin, Minnesota, Massachusetts, Maine and Kentucky.

Regulations as to gross weight and overloading must take into consideration two road factors. First the difference in road types, permitting heavier gross loads, and loads per inch of tire width on the more durable types, limiting both gross load and weight of wheel load on less durable types. Second in those states in which there are considerable climatic variation, restrictions should be imposed during the early spring, when the pavement is more easily destroyed than later when the frost has disappeared and the road is not susceptible to injury.

The second phase is the problem of overloading per truck capacity. My analysis deals primarily with this problem, which is by far the most serious. The limitation of loads to a maximum of 25,000 lb. does not prevent the overloading of trucks whose rated capacity falls below the maximum load provision.

At each of the census stations, the width of tire was taken by measuring the impression made by the wheel load, front and rear, after passing over strips of impression paper. The front and rear axle weight was procured in order to determine the total load, and distribution of load, on the front and rear axle. These figures enabled me to determine the wheel load per inch of tire width for each truck, make, and capacity. The make and capacity of the truck were necessary in order to compare the manufacturer's total weights, and percentage distribution of weights, front and rear axle, with the actual weights recorded, to arrive at the overloads per capacity.

Any analysis of overloading has certain limitations in the present state of highway research. (1) The lack of maintenance cost studies of the highways on which the surveys occurred, does not permit of establishing accurately the direct relationship which exists between overloading per capacity and high maintenance costs. (2) the effect of overloading on the pavement and subgrade can best be shown when correlated with impact studies of the several pavement types. (3) Criticism of the overload data on the basis of the standard used in determining overloads. The weight standard used to determine overloads for each make and capacity consists of a summation of the manufacturers' 1920 weights for the chassis, body, and rated capacity, giving the total weight when loaded to capacity. The percentage distribution of weight recommended by the manufacturers of trucks for front and rear axle load is used as a standard for determining overloads on the front and rear axle. In order to be conservative 5% of the total chassis, body and capacity weight was added to the manufacturers' given weight and used as the standard for computing total overloads per capacity. One-half of this 5% was added to the front and rear axle standard weights in arriving at overloads for the front and rear axle. For example, if the chassis weighs 7,000 lbs., the body 1,600 lb. capacity 7,000 lb., a total of 15,600 lb., 5½ of 15,600 lb., or 780 lb. was added, making a standard for total overloads for this capacity of 16,380 lb. In addition 390 lb. was added to the front and rear axle weight, and the totals used as a standard for judging the front and rear axle overload. This basis seemed fair, and even an allowance of 10% would have made little material difference in the result.

Types of Commodities in which Overloading Occurs

It has been generally believed that overloading has occurred primarily with trucks loaded with sand, gravel, brick, cement and lumber, and that this abuse was restricted to a relatively small group of commodities.

AVERAGE TYPES OF COMMODITIES IN WHICH OVERLOADING OCCURS.

Commodity	Second Connecticut Census, 1921. Overloads	Regular Trucking	Irregular Trucking
Apples	7	7	
Bananas	8	8	
Beer	18	15	3
Butter and Eggs	6	5	1
Cocoa Beans	6	6	
Crockery	4	3	1
Drugs	9	7	2
Dry Goods	9	7	2
Feed	4	4	
Fish	10	7	3
Fruit and Vegetables	17	15	2
Furniture	20	8	12
Grapes	9	5	4
Groceries	51	46	5
Household Goods	22	7	15
Lumber	13	4	9
Litharge	6	6	
Machinery	5	2	3
Meat Products	15	11	4
Merchandise	9	7	2
Paper	4	4	
Potatoes	4	3	1
Poultry	15	10	4
Rubber Goods	9	9	
Silk	10	10	
Sugar	18	12	6
Tarvia	4	3	1
Vegetables	16	14	2
Vinegar	5	2	3
Wire	8	8	
Totals	344	257	87
	Percentage	75%	25%

Note—Products overloaded numbering less than four cases not included in tabulation.

The types of commodities in which overloads occur per capacity, excluding all commodities in which the number of cases of overloads are less than four, range from apples to wire. Of the cases cited 75% of the overloading was practised by regular trucking vehicles.

COMMODITY LOADS IN EXCESS OF 25,000 LB.
Second Connecticut Census 1921.

Commodity	Loads	Overloads per capacity	Regular Trucking	Irregular Trucking
Brick	2	2	2	
Butter	1	1	1	
Cocoa Beans	5	1	[illegible]	
Drugs	1		1	
Eggs	1	1	1	
Fruit	6	5	6	
Glass	1	1	1	
Groceries	6	6	6	
Litharge	3	3	3	
Meat	2	2	2	
Plumbing Supplies	1	1	1	
Rubber	5	4	4	1
Sugar	8	8	5	[illegible]
Tarvia	2	2	2	
Valves	1	1	1	
Vegetables	1	1	1	
Vinegar	4	4	3	1
Totals	49	43	44	5
	Percentage	87.8%	88.7%	11.3%

The commodity loads exceeding 25,000 lb. in the second Connecticut census include such articles as the table above indicates. Of the total number in excess of 25,000 lb. gross weight 87.8% overloads per capacity, and 88.7% were overloads by regular trucking vehicles. Thirty-nine out of 41 cases were loaded from 846 lb. per inch of tire width to 1,560 lb. per inch of tire width on the rear axle.

RAILWAY DEPARTMENT FORMED BY WISCONSIN HIGHWAY COMMISSION

Through the formation of a Railway Department as an active branch of the Wisconsin State Highway Commission, definite recognition has been given to the necessity of careful planning in the relocation of highways and expert consideration of the question of eliminating grade crossings. In taking this step Wisconsin has again demonstrated its fitness in assuming a leading position as a good roads state. For years the Wisconsin system of concrete roads has been attracting the attention of highway officials from all parts of the country, while the splendid system of highway marking, originated by State Highway Engineer, A. R. Hirst, is justly famous.

M. W. Torkelson, former bridge engineer for the Wisconsin commission, has been placed at the head of the new Railway Department. His work will be chiefly connected with relocation of highways and elimination of grade crossings. The Wisconsin authorities are firmly convinced that many dangerous crossings can be eliminated by proper steps before expensive improvements are carried out, and that by careful relocation many of these crossings can be abolished altogether. Highway officials, as shown by the Wisconsin innovation, are realizing more and more that the duties of the state departments include not only the construction of good, durable roads, but precautions for the safety of the motoring public in the way of separated grades and properly located routes.

WILL TEST ROAD UNTIL IT FAILS

During the week beginning March 27 the Illinois Department of Public Works and Buildings, Division of Highways, will by means of a fleet of trucks, start the loading of the Bates Experimental Road, located near Springfield.

The test road was started in the summer of 1920 and completed early in 1921. It is about two miles in length and includes 63 sections. Each section differs from the other in thickness, material of which it is composed, or in design such that its carrying capacity might be affected. It is expected that as the loads carried by the trucks are increased, many if not all, of the sections will be destroyed. The behavior of the various sections in supporting truck loads is expected to give valuable information in the way of confirming or disproving theories which have been advanced as to the load supporting capacity of pavements of different thickness and different types.

It is expected that the testing of the road will be continued for several weeks or perhaps months.

Vigo County, Indiana, plans to construct 15.5 mi. of paved roads during the present year, according to Robert E. Gibbons, County Engineer.

Morgan County, Alabama, recently voted a $440,000 road bond issue and will soon let contracts for the improvement of a large mileage of country highways.

Road Work in Ouachita Parish, Louisiana, will be supervised by a committee of seven citizens recently appointed to hold office until June 1, 1924. Approximately $1,600,000 will be spent on road improvement in Ouachita Parish during the next two years.

The Widening of Washington Street, Portland, Ore., is recommended by O. Laugaard, City Engineer. He proposes to widen the street 15 ft. on each side by arcading the first stories of all buildings.

The City of Trenton, N. J., will soon let contracts for paving to cost approximately $275,000. The program includes new construction on 17 streets and repaving of 7 streets.

The Trenton, N. J., Department of Streets is conducting a campaign against ice cream wagons which allow salt water to drip upon the city streets, resulting in damage to the pavements. Trenton has an ordinance against allowing salt water to drip upon pavements.

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

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Copy for classified and other advertisements where proofs are not required will be accepted until noon on Monday of the week of issue.

Articles by road builders are solicited. They should be short and, if possible, accompanied by photographs. Those accepted will be paid for at current rates.

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GOOD ROADS AND THE FARMER

Considerable opposition to the carrying out of road programs is being voiced by the farmers of various states. Elsewhere in this issue appears an article by K. L. Hatch, Assistant Director of Agricultural Education of Wisconsin, in which he protests against the issuing of any more bond issues in that state and advocates the construction of lower types of roads.

"In Wisconsin," concludes Mr. Hatch, "the farm population represents approximately 50% of the voting power of the state and 55% of the assessed valuation. Approximately 80% of these farmers live on non-patrolled lines. This group represents, therefore, the large majority of the agricultural class. The Wisconsin farmer seldom speaks but he has power to make himself felt. He has silently supported the state's road building program and will continue to support it—but he has the right to ask 'More Miles for Less Money.' His demand will be heard."

While GOOD ROADS does not share the opinion of Mr. Hatch, his article is printed so that our readers may see the undercurrent that is flowing in the minds of farmers throughout the country. The value of farm products has declined very greatly during the past two years, yet the farmer's taxes have increased. Under these conditions such a reaction against road construction may be expected. "In 1919," says Mr. Hatch, "the crop of the United States had a farm value of 16 billion dollars. The crop of 1920 was worth scarcely 9 billion dollars, and figures just announced by the U. S. Department of Agriculture place the farm value of the 1921 crop at five and two-thirds billion dollars."

These protests on the part of farmers in various parts of the country must not be considered in the same light as were their opposition to the road movement a score of years ago. At that time the value of good roads was not appreciated; but since that time the farmers have been educated to the fact that improved roads are essential to their welfare. A careful study of the complaints of the farmers should be made.

The problems of highway finance are becoming more important each year. States and counties are piling up bonded indebtedness undreamed of a few decades ago. To get the most returns on the money invested highway officials must give serious thought to the raising and expenditure of road funds.

Governor Miller of New York, as pointed out in this column previously, has advised that the state issue no new bonds but that current revenues should be increased so as to provide sufficient funds to carry out its road program. Approximately one-third of the states have taxes on gasoline, yet a large amount of revenue can be raised by means of this tax. Many states could increase their motor vehicle fees and still others could increase their state taxes. By securing the maximum revenue possible from these three sources the problems of many states would be greatly simplified.

SNOW REMOVAL ON RURAL HIGHWAYS

Before the advent of the motor vehicle the matter of snow removal from rural highways was considered only when after a storm a section of road was impassable to horses and sleds. Even then the work was usually done by persons in the neighborhood who desired to communicate with the outside world. But now, with more than ten million motor vehicles traveling on the nation's highways, the problem of snow removal is very real and each year grows as the number of motor vehicles increase. "The amount of money to be spent on snow removal," writes C. J. Bennett, State Highway Commissioner of Connecticut elsewhere in this issue, "will only be limited by the value of service to traffic. The work is done for the purpose of providing facilities for the motor vehicle and should be included in the taxes on the motor vehicle."

UNUSUAL ROAD TESTS IN ILLINOIS

As noted elsewhere in this issue, a fleet of loaded trucks will start traveling over the Bates Experimental Road in Illinois and the loads will be increased until a number of the sections comprising the road fail. This road has 63 sections of pavements, varying in design and materials. The behavior of the different sections will be observed under the action of the heavy trucks and it is expected that considerable valuable data will be collected.

Snow Removal on Country Highways*

By C. J. BENNETT†

The purpose of the following discussion is: First, to justify the need of snow removal from highways outside of municipalities; second, to discuss the methods employed up to the present time in carrying out this work, pointing out the weaknesses; and third, to outline in general a suitable organization to efficiently remove snow on inter-urban highways where traffic may expect service from the highway for 365 days in the year.

Highway engineers today are firmly convinced that the motor vehicle, whether passenger or commercial, has a very definite place in the transportation scheme of the country; that the magnitude of operation of these motor vehicles varies widely in different sections, but that there is hardly any place in the United States where motor transport is not a material factor in the delivery of passengers and freight.

These locations vary in importance on account of the character of business done or the class of commodity handled. In certain sections of the country where manufactured products are the main articles of commerce, the motor truck for the transportation of freight, or the passenger car for the transportation of passengers, in order to fill its proper sphere must, of necessity, be operated during the entire year, or with only such minor delays or discontinuances as may be easily taken care of by a short cessation of business.

If business were arranged with regard to climate, some of the problems of the highway engineer as regards snow removal would be materially simplified, but it is interesting to know that at least in certain sections of the country one hundred per cent motor transportation is demanded, and in these sections, at certain times, snow falls in varying quantities and the problem of the engineer in its removal becomes a matter of very serious import.

Neglecting the argument that the removal of snow is of material benefit in the maintenance of the highway because the effect of removal on maintenance is slight, we must consider carefully the value of snow removal per se. No matter what we may say regarding highways or how much we may disregard traffic, one of the fundamental principles of highway engineering must be that the road is built for the purpose of carrying traffic. Such a statement at first glance seems unnecessary and ridiculous, yet there are those of us who at times would fain build a road simply for the purpose of performing an excellent piece of construction and for no other purpose. Such men are those who entirely disregard the accommodation of traffic during construction or who make the inevitable remark that in cases of snow storms: "Let the public stay home or use the trolleys."

Having established a system of transportation dependent partially upon the motor vehicle transportation, it would seem almost an axiom that every possible effort should be made to provide for the operation of this class of traffic at all times.

Previously, we have had little or no knowledge regarding the value of the road in actual units of cost. It has been easy heretofore, almost universally to provide other means of transportation when snow fell, but there are certain sections of the country, notably that from which the writer comes, where the use of motor vehicles cannot be discontinued without serious inconvenience to the public. May we not say, therefore, in closing this discussion that indications seem to prove that snow removal is necessary in those locations where motor vehicle transport has become a necessary factor in the commercial life of the community?

The added convenience to those who use the roads for passenger purposes for their own comfort or convenience, while not a commercial or economic factor, is certainly something to be taken into serious consideration. In other words, it may be justifiable, speaking in practical terms, to expend up to $300 per mile in order that the motor vehicle may get full use of the road instead of 50 to 60% of the use. This statement is further supported by the fact that in almost every instance of proper highway financing, we find the motor vehicle paying through license fees a sufficient amount of money to demand a 100% service from the roads, or a reduction in license fee in proportion to the time during the use of the roads may be discontinued.

Methods at Present in Vogue

We, all of us, are more or less familiar with the haphazard methods of snow removal employed, excepting in certain instances, and are familiar with the failures of these haphazard methods in particular cases. There are places, here and there, where snow removal has attained an important place in the work of the Department having in charge the maintenance of highways, but these departments are still in the minority, and the methods employed generally are insufficient and expensive.

Based on the previous discussion of the need for snow removal and giving due weight to the importance and magnitude of the work to be done, particularly in the snow belt regions, we must admit that the problem of snow removal, if worthy of serious consideration, should be given such study as to provide the proper method applicable to the location in which the work should be done.

Ideal methods of snow removel are, of course, impossible to define excepting in a general way. Certain

*Paper presented at Eighth Annual Conference on Highway Engineering of the University of Michigan.

†State Highway Commissioner of Connecticut.

principles should be laid down, in order that the work may be successful, we must provide for speed. The attack must be sudden and continuous until the work is finished. This means expense and a sacrifice of efficiency.

In general, the problem of snow removal varies between extremely wide limits. There are those sections where the fall is light in total, but where occasionally heavy snowfalls occur. In these sections, provision must be made for the complete removal of snow from interurban highways, for in these sectons the use of sleighs is practically unknown.

From this class of locality to the other extreme is a long jump, the other extreme being the places where snow fall is heavy and continuous and vehicular traffic, excepting over very much restricted distances, is unnecessary of consideration. In these localities, when winter comes, the use of the motor vehicle much be dispensed with unless its use becomes so important as to provide for heavy and continuous operations in snow removal.

The prediction is, however, made that on no main highway in the United States, with the exception of these places located at high altitudes, will we fail to remove snow for motor vehicle traffic in the course of the next ten years.

Organization

As regards the organization for carrying on the work, this should be formed generally around the organization having in charge the maintenance of the highway system. In general, the men used in the summer time for maintenance purposes may be subject to call, and the regular salaried personnel be used for supervising the work. In cases of extreme stress and emergency, advantage can be taken of local organizations or of contractors having special sources of labor or equipment. The work should be organized so that the necessary equipment is available at convenient points ready to go to work within a short distance of the point of storage. The work should be started immediately upon the commencement of the snowfall of any magnitude. In many instances, the snow will stop falling very soon, and some of the work will be wasted, but the advantages in the cases of extreme snowfalls of having the jump on the job will more than offset any loss due to work being done when unnecessary.

The organization should be reliable, well trained with a knowledge of the job and with sufficient confidence in itself to carry on the work if the ordinary methods of communication, such as the telegraph or telephone fail. In other words, each man should know his job, be willing to take the responsibility of carrying on the work to completion and be subjected to little, if any, blame if he makes serious mistakes, if these mistakes are honestly made.

The skeleton organization should be such that it covers the entire territory to be treated. There should be sufficient equipment available to do the job within a reasonable time and to do the job under maximum conditions rather than under average conditions. In other words, a great amount of equipment should be available and is absolutely necessary. This equipment should be in the very best of condition, housed in convenient and warm places, particularly in the case of motor trucks, so that it may take the character almost of a fire department subject to call in emergency and ready for the call without fail. This organization should be ready at any time, day or night.

No matter how large an organization may be attained, it will never be large enough to attack the problem of snow removal simultaneously at all points so as to clear the snow from all roads at the same time. In general, the problem resolves itself to those sections of highway which are more important and upon which the traffic may rightfully expect to pass within a reasonable time after the snowfall. In cases of continuous snowfall, it may be that the secondary routes will have to be neglected and traffic concentrated on the main routes.

In getting ready for the snow, we should take into consideration the cooperation with the United States Weather Bureau; but it is well not to rely too fully upon these reports because in many instances we have had snow storms which were not foretold by the Weather Department, although in general the service is of great value, supplementing our own efforts, particularly in cases of extreme storms.

Methods

Apparatus for the removal of snow from interurban highways should possess the vital quality of speed of movement. Such apparatus should be strong, rugged in construction, kept in good condition, and should be operated by men skilled in its use.

Inasmuch as the motor vehicle demands attention in traffic and is available in large numbers for work, particularly in the winter time, there is probably no more valuable agent for snow removal on highways than the motor vehicle with supplementary equipment.

Motor trucks have added advantage of being available for other purposes in the other seasons of the year, and does not call for such a large investment in plant as would be necessary if machinery were purchased for snow removal alone.

The degree of snow removal depends upon the class of traffic to be accommodated, which has been suggested above. Where traffic is diverse in character, there will be a constant strife between horse-drawn vehicles and the motor interests as to whether the road shall be suitable for wheel traffic or for horses. In general, a traffic census will determine very quickly which is the more important of these two agencies to accommodate, and the degree of removal can be measured by the magnitude of use of one or the other class of traffic. The width of removal depends again upon the amount of traffic to be accommodated, but in gen-

eral, on heavily traveled routes, at least, a sufficient width for two lines of vehicles should be cleared, and if possible, snow pushed back during earlier snowfalls so that future snow may be more easily disposed of. In certain instances, snow paths may be provided on the side of the road to accommodate horse-drawn traffic which otherwise would be seriously discommoded.

Apparatus

Apparatus for snow removal has not been developed as fast as the motor vehicle itself. This statement, of course, is also true regarding the development of the highway systems. In general, the work of the highway engineer has, of necessity, lagged behind the needs of transportation, simply because the general public has not been alive to the value of this method of accommodating traffic. Consequently, we are faced in the removal of snow with the same problem that we are in the construction and maintenance of highways. We have not developed our methods sufficiently to provide for snow removal, nor have we designed and constructed apparatus of a character to properly do the job.

In general, as outlined previously, the methods employed have been haphazard, and advantage has been taken of the equipment available such as horses, oxen and plows, hauled or pushed by trucks, but the time must come when special mechanical devices, capable of attaching to motor trucks, or even operated under their own power, must be designed for the purpose of snow removal. The use of animals for snow removal purposes should receive only a remark in passing that in certain sections of the country, the use of draft animals will always be of value in this work, but on interurban highways where the roads must be opened quickly for vehicular traffic, the use of animals is obsolete.

Modern snow removal naturally means the use of mechanical apparatus operated by gasoline motors; in other words, the truck with appliances attached, before or behind, or with a high class of mechanism designed particularly for the purpose of removal of snow. A great deal of advance has been made in the design and construction of this class of apparatus. At the present time, probably the most successful mechanical device and the most universally used is the scraper blade attached in front of a motor truck and set at an angle, used for the purpose of pushing the snow from one side to the other. Such a truck can be operated with continuous shifts of men if kept in good mechanical condition, and do an enormous amount of work, working 24 hours a day, even up to seven days a week.

Spare parts and repair facilities must be available, especially where the truck is used thus continuously. The number of these trucks to be used will, of course, depend upon the degree of snowfall and the amount of work to be done.

In general, the truck will propably clean a reasonable snowfall on 2 mi. of road in 24 hours, but in certain instances, the truck will be stalled so that it will only do a very small portion of this work in the case of an extremely heavy or wet snowfall.

In our section of the country, the weight of the snow varies between very wide limits. The light snow weighing from 12 to 14 lb. per cubic foot will often begin followed immediately by a fall of snow from 22 to 24 lbs. per cubic foot.

The apparatus for removal must be designed to handle the heavier snow, and yet must be operated carefully in the light snow to obviate breakages. The advantage of using the motor truck with the plow in front is, of course, that the truck may be used for other purposes in the summer time. The disadvantage is that the use of the truck for snow removal has a serious effect on the efficiency and life of the truck itself, especially when used for other purposes at other times. It is the opinion of the speaker that if the truck is used for a combination of snow removal and ordinary maintenance work, it should be charged up with 33% depreciation each year. In other words, the truck will be used up at the end of three years.

The use of this equipment is restricted, of course, to roads which have a reasonably hard surface and during snowfalls which are not seriously drifted. The drifting, of course, may be prevented by promptness in execution during the snowfalls or the proper installation of snow fences at danger points. Drifts may be removed or broken out by the use of tractors with plows in front or behind. In general, the placing of the plow before the truck provides better footing for the wheels, or traction device much better than if the scraper or plow were pulled.

As we get into the niceties of snow removal, we will however, find a use for other apparatus, some of it of the ordinary type, and much of it especially designed.

In order to start a discussion on this matter, it is the firm opinion of the writer that no method of snow melting or snow compression will ever be successfully operated due to the tremendous amount of heat or power necessary to melt the snow and to the probable defects due to freezing or choking of the apparatus itself, so that this discussion will neglect absolutely devices of this character and will confine itself principally to the mechanical means of removing snow in practically the same manner that earth is moved, although the material is of less weight per unit.

Viewed as an earth removal proposition, the apparatus designed for the removal of earth would be applicable to snow, excepting that the quantities of snow to be moved would be extremely large, and the allowable cost per unit must be very low, so that the devices for snow removal must be designed to handle quickly large quantities at a time and distribute the material in waste places without particular regard to

appearance. Consequently, the ordinary earth removal devices are inadequate because they are designed to carry heavy material, but modifications of these devices can be made to be accommodated to the handling of snow.

Modifications of the conveyor, loader, the steam shovel and the steam excavator can be made so that these can be applied to snow removal. Several types which indicate a study on the part of the manufacturers of equipment have been manufactured here and there realizing the magnitude of the snow removal problem.

We are familiar with the centrifugal plow which has been used in Canada. The difficulty with this machine is that it is only hauled by horses and is restricted to the speed at which horses can travel. It disposes of the snow by throwing it up in the air and deflecting it on the sides of the road; and in this respect, it is useful on interurban highways. The width of path cut is narrow, and the radius of operation limited. Possibly some modification of this machine using a motor vehicle instead of horses for the tractive agent may be devised.

Other snow removal machinery of special character is as follows:

The snow tank which collects large quantities of snow in a receptacle and loads it into trucks or carts. Such a machine is of great value in the city and may be applied to tthe removal of snow in country districts.

Then, we have a rotary broom similar to those operated by the trolley companies, which is operated by a special motor being set at an angle and being revolved in the opposite direction to the wheels of the truck so as to throw snow forward and to the side. The expense of installing these machines is, so far, the only drawback to their operation which can be justified in certain instances where the desire or demand for snow removal is more insistent.

There are other devices which are on the market at the present time and which are subject to examination. The writer has attempted to get information together regarding all the apparatus manufactured for snow removal purposes, and has seen quite a few advertisements and catalogs, none of which, however, seem to be in a condition to admit of very much discussion.

There is, of course, the snow compressing machinery. There is a snow removal machine which consists of a continuous belt with cutting baffles operated at a high speed by independent motor. There are rotary plows and deflective plows of all kinds, but none of these have come to the point where they can be successfully used. These are simply mentioned for purposes of discussion.

All our statements previously have been made looking toward the removal of snow. We must not close a discussion of this kind without making mention of the absolutely important need of taking measures for the prevention of snow drifts by the erection of snow fences or the removal of obstructions such as weeds hedges, board fences or anything of temporary character which will tend to cause snow drifts within the traveled portion of the highway.

Like the problem of snow removal the installation of snow fences requires forethought. It should not be left until the snow falls. Snow fences should be up before there is any possibility of snow drifts, and should remain in place by arrangement with abutting property owners until the possibility of snow has ceased. Snow fences can easily and cheaply be designed. There is no necessity of going into detail regarding the type of snow fence to be constructed. The location of the fence, however, is a vitally important factor.

In conclusion, let it be said that snow removal is a very real problem with state highway department maintenance crews; that it will be a very real problem and increase in magnitude as long as we have motor vehicles; that the amount of money to be expended on snow removal will only be limited by the value of service to traffic; that the cost of snow removal will vary from $50 to $250 per mile, and in cases of extreme snowfall, the cost may run even higher. Much of the work is thrown away, discouraging, and must be done over again. The permanent results are practically nothing. The work is done for the purpose of providing facilities for the motor vehicle and should be included in the taxes on the motor vehicle.

From an experience lasting over a considerable number of years in the fighting of snow, the writer has reached the point where he is extremely disturbed when the snow begins to fall, because it costs money to remove and the money might just as well be thrown away for all the effect the greater share of the expenditure has on the condition of the roads in the future.

MOTOR VEHICLES INCREASE

Approximately one million more vehicles were registered in the United States in 1921 than in 1920, according to figures prepared by the U. S. Bureau of Public Roads. Nearly $125,000,000 was collected in motor vehicle fees during 1921.

The Board of Revenue of Jefferson County, Alabama, recently authorized the construction of six roads at a total cost of $550,000 and bids will soon be received for the work. The program includes 12 mi. of bituminous to top on reconstructed base; 27 mi. of chert roads, and 11 mi. of grading.

The Virginia State Highway Department has started work of improving the road between West Norton and Appalachia with convict labor. The grade will be reduced, a number of sharp curves eliminated and the road widened to 16 ft. Surveys are also being made on the road between Norton and West Norton and the contract for paving with concrete will be let shortly.

Good Roads and the Farmer*

By K. L. HATCH†

Henry Ford forced the good roads issue and in the years to come the spirit of Henry Ford will stand guard over it for all time. To the Wisconsin Highway Commission belongs the credit for the outline of a good roads program which has placed Wisconsin among the progressive states of the country. Both plan and progress reflect the superior intelligence, foresight and vision of Wisconsin farmers. They have contributed liberally to the building and maintenance of good roads and have willingly submerged their individual interests for the good of the whole. This has made possible a trunk line system maintained by efficient patrols connecting the principal trade centers of the state. All this is good and as it should be and from these basic policies no intelligent Wisconsin farmer dissents.

But we have now reached a turning point in our economic life when it behooves all those engaged in public service to face the stern facts of economic depression and its disastrous consequences. In 1919 Wisconsin spent in round numbers 10 million dollars for good roads; in 1920, 15 million dollars; in 1921, 25 million dollars. During the same time the buying power of the farmer steadily declined. In 1919 the crops of the United States had a farm value fo 16 billion dollars. The crop of 1920 was worth scarcely 9 billion dollars, and figures just announced by the U. S. Department of Agriculture place the farm value of the 1921 crop at 5 2-3 billion dollars. Similar declines are shown in live stock values and while Wisconsin farmers may not have suffered in the same degree as those of other states, yet they have felt very keenly the results of price decline.

Thus we see that while expenditures for good roads have more than doubled in three years, during those selfsame years the farmers' buying power upon which his tax-paying ability depends has been reduced to one-third its size. Interpreted in terms of crops and live stock, good roads taxes are approximately seven times as high as they were three years ago. In other words, it takes seven times as many hogs and milk cows or acres of tobacco to pay the farmer's share of the good roads bills as it did three years ago.

On top of this, $37,000,000 has been added to the bonded indebtedness of 19 counties in the state. Provision must be made for meeting the interest on these bonds, when issued, and for their retirement which can only come from taxes. Bulletin No. 8 of the Tax Commission shows a tax expenditure for all purposes in Wisconsin for 1920 of over 112 million dollars, an increase of 26 million dollars in two years. Clearly this cannot go on. We can not continue to expand our road building program along the lines of our present policies in the face of these conditions, yet Wisconsin farmers demand better roads and more of them. It is evident that we must get more miles for less dollars and paradoxical as it may seem the thing can be done. For the next few years our slogan must be

"More Miles for Less Money"

But how? The first step has already been taken by the State Highway Commission when it refused to award contracts at present prices. Listen to the advice of your farmer friends.

1. Cut down hard surfaced construction to an absolute minimum until the costs of this construction reaches the same level of prices that the farmer receives for his products. Any large amount of hard-surfaced road construction at this time is unwarranted and wasteful.

2. Make re-locations only when necessary and when some large returns is to be obtained. Somehow Wisconsin farmers have come to feel that roads have been laid out from the standpoint of the engineer without due regard to construction cost, or agricultural values. Much unnecessary expense can be avoided and much fertile land saved to production if the farmer's needs as well as those of the motorist are considered in all re-locations.

3. Build more gravel roads. The farmer has seen the comparative values of these roads. He knows their relative cost and he sees in them the largest opportunity to get more miles for less money. He is demanding more gravel roads.

4. Extend the patrol system. Wisconsin farmers are thoroughly converted to the value of our state's patrol system and they demand its extension. This demand comes of course from those living "off" the trunk lines. They know what some members of the state's highway forces seem to have forgotten, that "a chain is no stronger than its weakest link," and the highway chain leading from their farms to town can carry no heavier load than can be gotten through the deepest mud-hole on this road. The patrol man constantly on the job looks after these weak links.

5. Start more permanent improvements. An extension of the patrol system to cover other than trunk lines means that permanent improvements must be begun before patrol can be made effective. Such roads must first be drained and properly graded. Hills must be cut down and hollows filled up. The grade, once established, remains as a permanent improvement for all time. As means permit these grades can be graveled or macadamized or hard-surfaced as necessity requires but they are absolutely necessary to effective patrol.

6. Give more attention to feeder roads. Many Wis-

*Paper presented at Wisconsin Road School.

†Assistant Director of Agricultural Extension of Wisconsin.

consin farmers feel that the weakest link in the chain of highways to their principal market is the feeder roads between the side roads and the trunk lines. The wettest, muddiest, most nearly impassible spots in our whole highway system often lie within ten feet of state trunk lines. Farmers attribute this neglect of thier rights to the habit of mind of the engineer whose one idea seems to be to get the motorist from "here to there" in the shortest possible time over a state trunk line. The farmer wants to "get there" too, but it is necessary for him to get on the line before he can possibly get there.

Summary

What the farmer wants then is adherence to the following program of "more miles for less money."

1. No more bond issues for hard surface road building and a minimum of costly construction until prices descend to his level.
2. No re-locations except when absolutely necessary.
3. More gravel roads.
4. More patrolled roads.
5. More permanent improvements of non-trunk roads.
6. Better feeder roads.

In Wisconsin the farm population represents approximately 50% of the voting power of the state and 55% of the assessed valuation. Approximately 80% of these farmers live on non-patrolled lines. This group represents, therefore, the large majority of the agricultural class. The Wisconsin farmer seldom speaks but he has power to make himself felt. He has silently supported the state's road building program and will continue to support it—but he has the right to ask "More Miles for Less Money." His demand will be heard.

MORE ROADS ARE NECESSARY SAYS A NEBRASKA FARMER

"Roads are of such importance that they may be compared to our lives; they are both good and bad; they are smooth, even, level, wide and full; they are hilly, narrow and winding; dangerous, shadowy and bright; and they show the effects of environment and care, even as we. They are the means of our life, for over them passes the food which must keep the people of the cities alive," writes a farmer in the Nebraska Department of Public Works Monthly Report.

"Without roads cities could not survive, and country folk would be without many of the present necessities, comforts, and luxuries of life, which they are now able to enjoy. They are the connecting link between the city business man, the manufacturer and the farmer, dairyman, the producer of food. They alone make it possible for both country and city to live up to our present standard of living and they will be largely responsible for any rise which may take place in that standard. Who, then, can place a value on roads, and who is great enough to say what their true service to mankind is? Can any man picture a country or a land without roads?

"A good man sets an example; a good road is likewise an example; and as we have too few good men, so have we too few good roads. Only when we find a travelable road going past every farm, through every village and city, will it be time to cease talking good roads."

ROAD PROGRAM OF INDIANA

The Indiana Highway Commission announced in detail on March 10 its road building program for 1922, all of the roads to be of hard surface and all to be federal aid projects. A total of 113.7 mi. make up the program and bids will be advertised for as soon as possible. The types of surface materials to be considered are concrete, brick and asphalt. The roads to be improved are:

Road No. 43 in Lake and Porter Counties known as the Dunes highway, skirting Lake Michigan. From Gary to Michigan state line, a distance of 21 mi.

Road No. 51, Elkhart to Michigan state line, distance of 4 mi. This road formerly known as Edwardsville road. Changed to Casopolis road and re-located to run due north out of Elkhart.

No. 2 (Lincoln Highway) for a distance of 3.5 mi. west of the Ideal Section. In Lake county. Also 7.7 mi. on same highway in Porter county just west of Valparaiso.

Ten miles on the Dixie Bee Line in Gibson and Vanderburg Counties known as the Haubstadt cut off.

Approximately 14 mi. on the National road between Brazil and Mt. Meridian. Twenty-one miles remains to be contracted for on this road, exclusive of 45 mi. contracted for in closing the five gaps the other day.

The commission set aside approximately $1,500,000 in a reserve for construction of gravel and stone roads on the state's secondary system.

The commission voted to take care of the Jackson highway from Seymour south to Louisville. It will grade the road first, which work will take about a year. Surfacing to follow will consume about a year.

Looking forward to adding the road from Palmyra to Corydon to the state system, the commission ordered Director Lyons to instruct the maintenance engineer to maintain the road from Salem to Palmyra.

It was brought to the attention of the commission the practice of farmers along the state system obstructing drainage ditches by constructing crossings and entrances from the highway to their land. The commission adopted the policy of property owners desiring such crossings must provide for the tile and the commission would provide the labor. This is essential, members of the commission state, if the drainage of state roads is to be maintained in the manner necessary for the high standard of roads desired.

MEETINGS

Calendar of Coming Meetings

June 4-6—American Association of Engineers—Annual convention, Salt Lake City, Utah. Secretary, C. E. Drayer, Chicago, Ill.

June 26-July 1—American Society for Testing Materials—Twenty-fifth annual meeting, Atlantic City, N. J. Secretary, C. L. Warwick, Engineers' Club Bldg., Philadephia, Pa.

Oct. 9-13—American Society for Municipal Improvements—Annual convention, Cleveland, O. Secretary, Charles Carroll Brown, Valparaiso, Ind.

ONTARIO GOOD ROADS ASSOCIATION

The twentieth annual convention of the Ontario Good Roads Association was held on March 1, 2 and 3 at Toronto, Canada, with the largest attendance in the history of the organization. On the first day committees were appointed and a number of addresses by various officials were given.

Among the papers presented were: "Road Building in Ontario," by Prevost Hubbard, of the Asphalt Association; "Lights on Vehicles," by John Currie, ex-warden of Middlesex; "Speed," by W. G. Robertson, of the Ontario Motor League; "Headlights," by G. C. Parker, of the Ontario Department of Highways.

"Highway Accounting," was the subject of the paper presented by Frank Pineo, Road Superintendent of Elgin County, Ontario. F. H. Richardson, Warden of Ontario County, spoke on "Provincial Highways—How Should They Be Paid For?" F. W. McKay, County Clerk of Elgin County, spoke on "Assessment in Proportion to Benefit," urging the increasing of the proportion borne by local assessments.

On the last day a general discussion on whether the Provincial Government should bear the full cost of the construction of provincial highways was held. It was the feeling of many that provincial highways should be financed entirely by the Provincial Government. However, a resolution to this effect failed of passage.

The following officers were elected: president, W. H. Brown; honorary presidents, L. E. Allen and T. J. Mahony; first vice-president, John Currie; second vice-president, George S. Henry; directors, J. E. Jamieson, F. A. Senecal, W. H. Nugent, Alvin Rose, Peter Ray and F. Richardson.

NEW DU PONT DYNAMITE

A newly developed dynamite which, it is announced, will prove an important factor in reducing explosives costs in quarrying, road building, construction and other open work has just been perfected by the Du Pont Company.

The new powder is known as "Dumorite" and is made with a double base of modified nitroglycerin and guncotton. It cannot freeze and does not produce headache.

In putting "Dumorite" on the market, the Du Pont Company announces that the explosive will effect savings of one-third on the dollar. It is as powerful, stick for stick, under ordinary conditions, as regular forty per cent dynamite, its economy consisting in the fact that each case contains approximately one-third more sticks.

"Dumorite" is a free-running explosive. It is stated to be quick and of great bulk strength. Before it was perfected, several hundred trial mixings were made up, all of which were carefully studied and analyzed by explosive experts. The final explosive was then subjected to every possible laboratory test. It was afterwards taken to the field where it was tried out in actual work under varying conditions as to temperature, rock and kind of work. The results proved the new explosive to be especially adaptable for open work in quarries, construction and agricultural fields.

The State of West Virginia plans to spend about $6,000,000 on road work during 1922, according to a recent estimate.

Maricopa County, Arizona, recently awarded the contract for 168 mi. of concrete highways to Twohy Bros.

PERSONAL MENTION

John A. Vogelson has been appointed chief of surveys for the City of Philadelphia, Pa.

J. F. Price has resigned as road supervisor of Venango Township, Erie County, Pennsylvania.

E. R. Thomas has resigned as city engineer of Port Arthur, Tex.

D. H. Knight has bene appointed city engineer of Frankfort, Ind., succeeding W. R. Payne, resigned.

J. W. Layle has been appointed superintendent of highways of Fort Erie, Ont., Canada.

Alva Smith has resigned as city engineer of Emporia, Kan.

Charles A. Browne, formerly state highway engineer of Florida, has been appointed county engineer of Orange County, Florida.

W. E. Shedden has been appointed city engineer of Jacksonville, Fla., succeeding F. M. Edwards.

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TABLE OF CONTENTS

Bituminous Surfaces on Gravel Roads. By Paul D. Sargent 179

Controlling the Quality of Materials in Highway Construction and Maintenance. By John H. Bateman 183

Road Work Will Relieve Unemployment 189

Hearings on Federal Aid Bill 189

Cost of Paving Compiled on Various Types of Material 189

New Jersey Passes Bond Issue 189

Third of Trucks Overloaded on Massachusetts Highways 190

Local Highways Becoming Long-Haul Thoroughfares 190

Wisconsin Buys Cement for Roads 190

Brooklyn to Have Asphalt Plant 190

EDITORIALS:

Federal Aid Appropriations 185

Standardization of Road Materials 185

MEETINGS:

Calendar 190

PERSONAL MENTION 190

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Vol. LXII. NEW YORK, N. Y., MARCH 29, 1922 Number 13

Bituminous Surfaces on Gravel Roads*

By PAUL D. SARGENT†

For the last eight years the Maine State Highway Commission has been surface treating gravel roads with success. During that time we have used exclusively a refined tar product suitable for cold application. We were let to this conclusion after an experience covering four or five years with various asphaltic oil and tar products. Where the two types of material were used on stretches of road contiguous to each other and conditions were as nearly identical as it would be possible to have them and both sections carried the same traffic, we learned from experience that the tar products gave us a much more stable surface and that it lasted two or three months longer in the fall after freezing nights and thawing temperatures during the daytime prevailed.

We also found that the tar products after about a week's time took their set and with the exception of possible softening on extremely hot days gave no further trouble after completion of the application. On the other hand, asphaltic oils many times would soften up during a protracted rainy period, more or less emulsifying, and resulted in a very disagreeable surface condition. This condition was also very marked during the period of freezing temperatures during the night and melting temperatures during the daytime, which lasts with us sometimes for three or four weeks in the fall.

I believe it may be of interest to relate some of the experiences from which our standard practice in the surface treatment of gravel roads with bituminous material has been developed.

Some eight or nine years ago when we first tried these treatments the principal use of surface applications was for the purpose of allaying dust. Light asphaltic oil, known as "45 per cent oil" was generally used for that purpose. The real effect of the oil always appeared to me to be merely to load the dusty surface particles of the road with so much weight that when stirred up by passing traffic these particles did not rise very much above the road surface and consequently were not blown and moved around much. Naturally, we more or less followed in our early tar applications methods in vogue at that time. We attempted to get a true crown on our gravel roads by adding an inch or one and one-half inch of new gravel where necessary and then by the use of a drag or light grader truing up the surface before the application of the bituminous material. The first year this work was done on any scale we applied our bituminous material in two applications. In May we used about four-tenths of a gallon to the square yard and about the first of August retreated all of these surfaces with an additional two-tenths of a gallon per square yard. Treatment was laid only 10 ft. wide. The real thing we sought to do with this treatment was to bond the loose surface material to the tightly bonded surface below it, and we accomplished this result fairly well.

By the end of the season, however, we observed that on certain sections of our roads so treated there was a slight rippling and waving of the surface. It occurred to us that this might be on account of the fact that we had not secured an effective bond between the loose surface particles of the road and the tightly bonded gravel beneath. In other words, the material which had been impregnated with tar had laid more or less as a mat upon the surface and not being sufficiently filled with mineral aggregate had pushed.

We had obtained, however, a much more satisfactory surface, generally speaking, than we had ever before seen on any surface treated road. The good sections presented the appearance of a first-class bituminous macadam surface, tightly sealed, smooth and dustless. As might have been expected, the edges of the bituminous treated section sheered off and crumbled away on account of so much traffic turning out for passing.

Our next development was an attempt to clean the gravel surfaces before the application of the tar. This was accomplished by the use of graders and drags and later by using a street sweeper and finally by follow-

*Paper presented at Eighth Annual Conference on Highway Engineering of the University of Michigan.

†Chief Highway Engineer of Maine.

ing that with hand sweeping. We also increased the width of our treatments to 15 ft. We found that all of these steps gave us a much improved surface and in fact since the first year we have used tar we have never made but one application to any gravel surface during a season. No sand covering was used during our first two or three years of treatmnet. The tar was applied on warm, dry days from an automobile tank distributor under pressure and we just allowed the tar to lie on the road until it was absorbed and took its set.

Needless to say we had much complaint from the traveling public on account of the dangerous condition of a freshly tarred surface for rubber-tired traffic. We attempted to obviate this danger as far as possible by treating one side of the road at a time. We would do a considerable stretch of road, anywhere from six to ten miles long, and treat it on one side only. While the treatment was being put on the first side the other half of the road was left open for traffic and by the time we had the first half finished the tar that had been first laid was well enough set so that traffic could go on it. Then the other half of the road would be treated in the same way.

We observed, of course, that steel-tired traffic wherever it ran on the freshly tarred surface stripped the bituminous material from the surface. This made it necessary to do more or less patching by hand. Also, on account of the increasing automobile traffic, which was continually getting on to the freshly tarred surface, we found it necessary to sand the tarred surface a few hours after application.

For the last three or four years we have made a practice of treating all of our surfaces 18 ft. in width, which has practically obviated the necessity of any patching on the shoulders or edges of the treated surface. Eighteen feet in width, which by the way is our standard width of pavements and hard surfaces today, affords a good double track way. We have been following the practice during the last three or four years of immediately covering the bituminous material with a light application of sand. By immediately, I mean that within five or ten minutes after the distributor has delivered tar to the surface of the road it has been covered with sand.

There are one or two points about sanding that I think should be spoken of. We place the sanding gang at intervals of 150 to 200 ft. apart, according to the length of road that the tank of tar will cover. Immediately the tar tank has passed, these men begin to sand and the sanding is started at the center of the road and first a place is made where passing vehicles may turn out on the freshly tarred surface. This affords traffic meeting places at stated intervals, so that with careful driving it is not necessary for a vehicle to become smeared or spattered with tar or to take the risk of skidding incident to driving on a freshly tarred surface. Our sanders are also instructed to keep an eye to the traffic so in case anyone gets into difficulty we will have some witness as to what actually happened. These men also caution drivers to be careful. Where we are applying tar over a summit grade we always plan to have a sander stationed at the summit to keep an eye to passing vehicles and to warn them against collision. These are points we have learned from experience and we have found them to pay. I offer the suggestions for what they are worth.

I might say that in general we have developed the following standard practice: As early as we can get on the roads in the spring, that is, when the roads begin to settle and dry out after the frost has left them, we begin shaping with the road grader. The roads are carefully watched during the two or three weeks while they are settling and are shaped either with a drag or blade grader several times if necessary to have them settle with as true a contour as possible. The next step in our surface treatment is to draw out sand, which is left on the shoulder of the road in piles of about a quarter of a yard every 25 ft. Generally speaking, we use about 50 yd. of sand to a mile for cover. We use less sand, however, on a new treatment than we do on retreatment. Sometimes as little as 30 yd. to a mile is used on the original treatment. Retreatments will take 40 to 50 yd. per mile, as the tar has less opportunity to penetrate into the surface of the road. The next step is to clean the surface of the road of all loose material. If a pocket of sand, dust or stone is left on the surface we are absolutely sure to have the treatment break over that pocket in a short time after application. This cleaning is done by the use of a street sweeper behind a light truck and if further cleaning is necessary after the sweeper has finished this is done by men with push-brooms. Then comes the tar distributing gang, which is equipped with pressure distributors mounted on three and one-half ton trucks. We have limited ourselves to this size of equipment because it is as heavy as our roads, generally speaking, will carry. We have a law which limits the gross weight of load to nine tons, and I am free to say that one of these 600-gal. tanks filled with bituminous material will a little exceed the limit set up by statute for the gross weight of load. Under average conditions one tank truck will spread about 2,500 gal. of tar per day. We still hold to the practice of tarring one side of the road at a time and several days may elapse between the tarring of the first side and the tarring of the remainder of the road. As pointed out above, immediately after the tar is applied a light sanding is given. We put on just enough sand to fairly blot the bituminous material and keep it from running off the crown of the road to the edge. The surface is carefully watched for three or four days and if evidence of bleeding shows up, spots where this occurs are treated with more sand. Sometimes after a treatment has been down for two or three weeks an extremely hot day will start a lit-

tle bleeding. This is watched carefully by the patrolman and the same treatment of light sanding given.

In the treatment of new gravel surfaces, that is, surfaces which have never received a treatment before, but which may have taken traffic anywhere from two to five years with an occasional resurfacing of gravel, we use not to exceed half a gallon per square yard, and in more cases probably use four-tenths to forty-five-hundredths of a gallon per square yard for the treatment. The amount of material depends upon the tightness of the surface. We have found that the smallest quantity of material we can use and get the surface covered gives us the best result. With a small quantity we never have trouble from rippling or waving of the surface, provided the gravel is in proper shape to receive the treatment when it is given, that is, thoroughly bonded and tight with no pockets of loose gravel, dust, or other material. We also find that surfaces which have received a small quantity of tar can be retreated for a longer time than surfaces which have been given a heavier treatment. Those which have received the heavier treatments will ripple and get out of shape, say in two, three or four years, while sections receiving a light treatment can be maintained without breaking up for a considerably longer time.

It must be borne in mind that the addition of the bituminous surface treatment to a gravel road does nothing but preserve the surface against disintegration from passing traffic. It does not materially strengthen the road in the sense that it will cause the road to carry heavier loads than the gravel surface itself or the foundation upon which it is laid will sustain. Surface treatment will not supply or take the place of drainage.

Our surface treated sections are kept under constant patrol maintenance. We patrol these roads with a light truck and two men and they are assigned sections anywhere from 12 to 18 mi. long. Besides watching the bituminous surface and mending any small breaks that may occur—and we have these breaks occasionally—and patching the shoulders, these men also keep the dirt shoulders shaped by dragging, keeping the gutters and culverts clear, and do whatever other work is necessary. We supply about three barrels of bituminous material like that with which the road is treated for each mile of surface. This material is mixed with sand and kept in stock piles. The mixing is usually done by hand and we use about 17 gal. of tar to a cubic yard of sand. In a few instances we have used a small concrete mixer to prepare the tar and sand for patching and we have been able to use as little as 14 gal. to a yard of sand when the mixing is done in a concrete mixer. Patches are made by simply cleaning out the hole, throwing in the mixture of bituminous material and sand and patting it in with a shovel. Any bad breaks on the shoulders are repaired the same way.

The most of our gravel treated surfaces do not remain intact over the spring period, a good deal of it breaks up. This is due to several causes. An open winter which allows the frost to penetrate deeply into the roadbed and allows traffic to run all winter long, or heavy traffic coming on these surfaces when the frost is leaving and the surfaces are soft will break up and generally disintegrate the surfaces. This really is more or less of an advantage, because it obviates the necessity of breaking up these surfaces and we save just that much expense in getting the surface ready for subsequent treatments. I have in mind one section of gravel road which was surface treated during the summer of 1920. Most everyone called it a good section of road, in fact, many automobiles have referred to it as bituminous macadam and many of our citizens refer to our surface treated gravel roads as bituminous macadam roads, especially when they want to tell about a bituminous road the highway commission has built which has failed in the winter. The particular section I refer to was so bad during March, 1921, that automobiles could not pass over it, or through it. For four or five miles this piece of road was literally a sea of mud for a period of about three weeks. Of course the surface treatment completely disappeared. We reshaped the road as it dried out and retreated it last spring. It presented a good surface all through the summer and fall until it was covered with snow. I apprehend that the coming spring will be a repetition of the spring of 1921. The road will be in about as bad condition as it was then but by the middle of June it will look like a boulevard.

On the other hand, I have in mind one section of surface treated gravel road which is built on a sandy foundation where the drainage is perfect that has never broken up during the last eight years. It gets a retreatment about every other year, maybe one-sixth or one-seventh of a gallon, as the gang goes by, and during the intervening year it does not get treated. This particular section shows evidences of slight ripples. It is on our heaviest traveled line, where the snow leaves earliest in the spring and we have the most severe truck traffic in the state.

We have a good many sections of surface treated gravel roads which do not break up in the spring. The most of these sections get a retreatment each year. The second year the amount of tar which we have used has been from three-tenths to one-third of a gallon per square yard. For the third and fourth years the amount has run as light as one-quarter of a gallon, and in some instances two-tenths. These surfaces are quite apt, however, after three or four retreatments to become ripply enough so as to be uncomfortable to ride over. This condition is due to a combination of reasons. One is that we may have as much as one and one-half or two inches of tar penetration which becomes separated from the gravel road itself on account of the passage of heavy loads when the frost is coming out of the roads and the whole roadbed is more or less soft. Where this tendency exists at all it is

always more pronounced where the surface has received successive treatments than where only one or two treatments have been given. Each year we have to break up more or less of this kind of surface and get the road in shape for new treatment. The method used is about as follows: We take a section of road about 1,000 ft. long; it is broken up either by using a pressure scarifier on a steam roller or by using a heavy blade grinder behind a truck or a roller and setting the blade so that it will do more of a plowing operation than a scraping one. The bituminous surface is in this way broken up into chunks anywhere from 2 in. to 2 or 3 ft. square. We next take a road grader and scrape this whole surface off to the shoulder of the road, then we plane the roadbed below to as true a surface longitudinally and transversely as possible. We then work back a portion of the bituminous bound material from the shoulder, distributing it over the surface. In this distributing operation the bituminous bound gravel is broken up more or less into small chunks. We then leave the road for two or three days for traffic, which materially helps in further breaking up these pieces of bituminous bound gravel, then the road grader is brought on and further working of the surface is given just by pushing the chunks around and pulling in more from the sides. By watching the surface carefully and using the road grader every two or three days we have been able to get the surface back into reasonably smooth condition. It presents more or less of a mottled or mosaic appearance. Gravel which has been covered with bituminous material has lost its binding property and it is necessary quite often to add a bit of good binding material here and there to complete the bonding of the surface. This binding material is used sparingly. We do not intend to have enough to leave any appreciable amount of dust to be swept off prior to the new treatment. As soon as we have the surface in shape we plan to immediately give it a new application of tar. We find that one of these surfaces broken up and reshaped as just described is very hard to keep in true contour under traffic and if it is allowed to go say two weeks we may have to break it up and rebond it before the tar surface treatment is given, else it would be so uneven as to be a bad riding road all through the season. Experience has shown that one of these old tar surfaces can be scarified and broken up more easily when the temperature is between 60 and 70° F. than during cooler weather. Good warm sunny weather also materially assists in breaking up the chunks of tarred gravel which are left on the surface of the road.

One thing we have satisfied ourselves upon is the fact that we cannot successfully apply tar surface treatment on a wet road or on a damp road. We have also had the experience of rain falling within two or three hours after tar has been applied and before the tar has taken any set and with traffic of one to two hundred cars per hour this has resulted in making a mushy surface which it is practically impossible to true up and make satisfactory. We have practically come to the conclusion that when this condition prevails we would do better to scrape the new tar surface right off on the shoulder, throw it away, reshape our road and put on a new application of tar. We will spend more money in patching the surface which is laid under these conditions than it would cost to replace the surface, and such surface after patching has never been satisfactory.

During the last four years our surface treatment work, plus the cost of patrol maintenance, for a season of eight months has averaged to cost $1,000 per mile. We estimate sand to cost us an average of $2 per cubic yard delivered in piles alongside the road. Tar costs us $0.12 in tank cars delivered on the nearest railroad siding. We figure the cost of applying the tar at $0.02 per gallon. Sanding costs about $0.75 per cubic yard of sand. Using 4,000 gallons of tar per mile gives us a cost for tar on the roadbed of $560; fifty yards of sand will cost $100, applying the same $37.50, making the cost of the tar treatment covered with sand $697.50.

The average cost of shaping and getting the surface ready for treatment in the early spring would be about $25 per mile. We use ordinarily a two-ton truck to draw the road machine. The truck rental would be $10 per day, the driver's pay $3.75 and a helper $3. The rental of the road grader is figured at $2 per day. Gas and oil will run from $5 to $6 a day. This outfit will average to smooth 4 mi. per day. Usually on the first smoothing we make about four round trips per mile. On subsequent smoothings possibly two trips will do; it all depends upon the condition of the road when it is smoothed and the subsequent condition of rain and settling of the road.

For sweeping we use a mechanical sweeper drawn by a light truck, say a three-quarter-ton or a one-ton truck. We usually make four round trips with the sweeper, and this outfit will sweep about 2 mi. per day, as we can only run the sweeper about three miles per hour. The expense for sweeping would run about as follows:

Truck rental, $5; oil and gas, $2; driver, $3.75; helper, $3; rental of sweeper, $2, making a total of $15.75. or an expense of sweeping at $7.87 per mile.

The balance of the $1,000 is paid for patrolling the road through the season. The usual patrol gang on bituminous surface treated gravel roads is a patrolman with a one-ton truck and helper. According to the amount of traffic and the condition of the road, this outfit will cover anywhere from twelve to eighteen miles of road. The outfit costs $13.75 per day, made up as follows:

Rental of one-ton truck, $5; gas and oil, $2; Patrolman, who drives the truck, $3.75; helper, $3.

These gangs work an average of two hundred days

per year, so if the patrol section was 13.75 mi. long the average cost per mile would be just $200.

Based on the figures given above, this would show a maintenance cost of $930.37 per mile. I have said that on new roads we use half a gallon of tar per square yard. That will increase the cost $140 per mile over the figures already given.

Where it is necessary to scarify or break up the old bituminous surface, we run into a considerably larger expense for preparing the surface then indicated above. I think I have given enough explanation, however, to show that the average cost is very close to $1,000 per mile.

There is one point that I neglected to mention, and that is that quite often in making an original treatment if traffic is running fairly heavy and it will take us six or eight days to treat the section we are working upon, we will slide over the road with a priming coat of the tar material, using two-tenths to one-quarter of a gallon per square yard, the quantity depending upon the tightness of the surface. This will hold our surface in perfect condition under traffic for a week or ten days. We immediately apply the balance of the quantity, sand, and finish up the job. We have almost come to the conclusion that it would be good practice to do the priming everywhere on new surfaces. It gives a better penetration of the bituminous material, besides holding the surface in proper contour until the treatment can be completed.

I ought to state before closing that we have many miles of surface treated gravel roads which are carrying a twelve-hour traffic, from 7 A. M. to 7 P. M., averaging from 2,300 to 3,500 vehicles per day for a week's time, with a maximum traffic during the twelve-hour period of as high as 5,500. This traffic continues for a period of four to five months, from the middle of May until well toward the first of October.

We find it impossible to hold our gravel surfaces in satisfactory condition by ordinary patrol maintenance methods, that is, dragging and patching with gravel, when the traffic exceeds 500 to 600 vehicles per twelve-hour day, and the expense of such maintenance runs about $500 per mile.

The material which we use for surface treatment falls within the specification T.C.-1, Tar for cold application, Bulletin No. 691, U. S. Department of Agriculture.

Credit for the most of the developments we have made in surface treatment of gravel roads is due to Mr. A. J. Wiggin, Superintendent of Maintenance of the Maine State Highway Department.

Controlling the Quality of Materials in Highway Construction and Maintenance*

By JOHN H. BATEMAN†

Highway construction and maintenance are effected by a great many factors all of which are of more or less importance in the successful prosecution of work. Leaving out of consideration administration and financing and considering the items of construction and maintenance, we may quite probably consider two factors which are necessary to attain good results. These two factors are: good workmanship and a good quality of materials. The inspection of construction and maintenance work deals to a very large extent with these two factors and the careful inspection of both is necessary to insure good work. The necessity for this inspection may generally be considered as due to three principal causes: first, an intent on the part of the construction organization or the producers of materials to actually do poor work or furnish low grade materials; second, carelessness on the part of employes, and third, ignorance of the work, due to unfamiliarity or lack of training or experience. The first of these reasons is probably responsible to only a small degree for the necessity of careful inspection of materials. The latter two reasons are probably responsible in a much higher degree for the presence of a poor quality of material on any work.

Under inspection of materials we should also include the necessity or desirability of the work of controlling the proper use of these materials.

The control of quality of materials in highway construction and maintenance, as in other forms of construction and maintenance work, is of a two-fold nature involving both laboratory methods of examination and field testing. These two factors are not distinctly separate operations, but are bound together by reason of the nature of the work, and the successful control of materials depends entirely upon the proper relationship existing between a laboratory and field inspection forces.

Laboratory methods of examination in many cases are necessary because of the difference in methods of analysis of the many materials entering into the construction and maintenance of highways. In the case of many materials proper examination consists of both laboratory and field work. A brief description of some of the more important tests of various materials may be used to illustrate this relationship.

We are all familiar with the various tests of Port-

*Paper presented at Eighth Annual Conference on Highway Engineering at the University of Michigan.

†Director, State Highway Laboratory, University of Michigan.

land cement which have now been adopted as standard over practically the entire country. These tests must necessarily be conducted under rather strict conditions as to apparatus, temperature and other working conditions and make laboratory examination a necessity. The examination of Portland cement involves tests which may be grouped into three classes as far as the element of time is concerned: first, we have those tests which may be completed within a period of 24 hours; second, strength tests which may be completed at the end of 7 days, and third, strength tests which may be completed at the end of 28 days. Portland cement is usually required to satisfactorily pass all of these tests, but on account of the long time intervening between the beginning and completion of all the tests, it has usually been the custom to provide for the acceptance of Portland cement on the basis of 24-hour or seven-day tests, either tentatively or entirely reserving the right to require in one case seven and 28-day tests, and in the other 28-day tests in the case the cement fails on either seven-day or 28-day tests after having passed preliminary tests referred to.

In the examination of sand, gravel, crushed stone and crushed slag, the services of a laboratory may properly be made use of most especially in the examination of preliminary samples. After the quality of these materials has been definitely determined and proper control may well be said to be a duty of the field inspector.

The examination of ledge rock, on account of the character of the tests involved, makes laboratory tests a necessity. The tests ordinarily conducted to determine physical qualities are: hardness, toughness, abrasion and compressive strength. These tests all require more or less expensive and heavy machinery which, for economy, must be located in a rather extensively equipped laboratory. After the quality of a certain product has been determined, further tests are not usually necessary within a period of one year's time of making the initial tests in those portions of the quarry at which operations are being carried out.

Proper inspection of paving brick involves the utilization of machinery which may only be properly installed in a laboratory, either at the plant itself, or in a central laboratory for the exmination of such materials.

The quality of asphalt and tar products also involves the utilization of a properly equipped laboratory on account of the exacting methods of analysis required in this industry. The relationship between labaratory and field examination will be touched on at a later point in this discussion.

In addition to these materials we have other materials, such as structural and reinforcing steel, corrugated metal pipe, paint and others which represent materials for which laboratory methods of examination are necessary.

As I have stated before, the proper examination of materials involves both laboratory and field methods. Most of us are familiar, at least to a certain extent, with the various methods utilized in the laboratory. Many recent developments, however, in the connection with desirable field control of materials are of particular interest and value at this time. It is my purpose to describe some of these various methods in an attempt to point out their value and the relationship which should exist between field and laboratory inspection with various materials.

Field work involves one of the most important of the operations in connection with all testing. I refer to the matter of sampling of materials. It is perfectly evident to all of us that the the proper interpretation of results of tests conducted, either in the field or in a laboratory is necessarily dependent upon the method which has been used in obtaining the sample for examination. It may not be amiss to describe, in connection with various materials, some features of sampling which must be carefully observed in order to insure obtaining test results which are representative of the bulk of the material sampled and tested. In this connection we may refer to three features as the principal factors which must be observed in connection with sampling operations; first, the method of sampling must be such that the sample taken represents as accurately as possible the bulk of material sampled; second, the size of the sample must conform to the quantity of material necessary for conducting tests, plus an extra quantity to retain for reference purposes; and third, the container to be used in transmitting the sample of material from the point of sampling to the laboratory must be of satisfactory kind and size.

Portland cement is used in very large quantities in both highway construction and maintenance. The necessity for careful sampling is quite evident on account of the method of manufacture and shipment of this material. It is now generally recognized that a sample of Portland cement should be taken from every 200 to 250 barrels of material, thus quantity being approximately that contained in one carload. Portland cement is shipped in cloth or paper sacks, or in bulk. In taking samples from shipments in sacks, a small amount—let us say about ½ pound—should be taken from each of about twenty sacks selected at random from a carload or an equal amount of cement. It is not necessary to open up the sack of cement to obtain the sample. A small valve is placed in the end of both cloth and paper sacks to be used for filling by means of the automatic sacking machines now generally used in all Portland cement plants. A small sampling tube may be inserted through these valve openings and the necessary quantity of cement obtained in this way without disturbing the sack itself. In the case of bulk shipments of cement, the most satisfactory method of sampling is by means of sampling rods with which we may be sure to reach all parts of the material. Cement samples

(Continued on Page 186)

GOOD ROADS

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Articles by road builders are solicited. They should be short and, if possible, accompanied by photographs. Those accepted will be paid for at current rates.

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FEDERAL AID APPROPRIATIONS

Two weeks ago the House Committee on Roads began to hold hearings on the Woodruff Bill, which provides appropriations of fifty, sixty-five and seventy-five million dollars for federal aid for the next three fiscal years, respectively. While Congress realizes the necessity of the immediate construction of a national system of highways, many members feel that road appropriations should be reduced in line with the spirit of economy now prevailing. Thus the problem of federal aid appropriations at the present time is not whether federal aid should be continued, but rather how fast the work will be allowed to progress. According to W. C. Markheim, counsel for the American Association of State Highway Officials, who appeared before the committee, approximately 117,000 mi. of highway must be built to complete the seven per cent. system of interstate highways designated by the federal highway act of last year. At $18,000 per mile, it would require an annual appropriation of $100,000,000 by Congress for ten years before this system would be completed. But if only $50,000,000 is appropriated annually, this interstate system of highways will not be completed until the end of twenty years.

Accordingly, the matter resolves itself into the question whether it will be most economical to complete this system in ten or twenty years. To our mind good roads can not be constructed fast enough to care for the increasing transportation demands of the country and there should be no hesitancy in appropriating, not smaller, but larger amounts of federal aid funds.

During the present year only $75,000,000 of federal aid was made available, notwithstanding the fact that the country is passing through one of the greatest business depressions in its history. During business depressions public works construction should be speeded so as to stabilize economic conditions. The road appropriation for this year instead of being cut from $100,000,000 to $75,000,000, ought to have been increased to $150,000,000. Unemployment and trade stagnation continue to exist. While we may "have turned the corner" there are apparently a few more corners to turn before we strike the main road to business prosperity. The demand for increased public works activity is just as great as it was a year ago; hence by making larger federal aid appropriations for the next two years Congress could expedite the completion of our much-needed highway system and at the same time greatly relieve the economic situation.

STANDARDIZATION OF ROAD MATERIALS

Representatives of the state highway departments of Virginia, West Virginia, Kentucky, Pennsylvania, Maryland, Delaware and New Jersey recently conferred with the U: S. Bureau of Public Roads relative to standardization of highway materials specifications. As it is now each state draws up its own specifications for materials, and stone or sand that may be permitted to be used in one state may be barred from use in another state because of differences in specifications. It is planned by the bureau to hold similar conferences with highway officials from other groups of states.

The standardization of materials specifications will do much to promote efficiency in road building. Minor variations in the requirements of sand, gravel, crushed stone, asphalt, brick and other paving materials very often cause much inconvenience to the plants producing them, thereby slowing down production and reducing efficiency. Surely a road material used for a certain purpose in one state ought not be required to pass different tests to be used for the same purpose in another state.

Last year a conference under the auspices of the U. S. Department of Commerce reduced the number of sizes and varieties of paving brick from 66 to 11. At the convention of the American Road Builders' Association held January Duff Abrams stated that many of the tests used on mineral aggregate are of little value. Thus it appears that materials specifications now in use by the various states should be examined both with view of simplifying the number of forms and placing the tests on a scientific basis. In times past elaborate, yet meaningless, materials specifications have been used. The present trend is toward simplification and the elimination of finely drawn specifications of dubious value.

LABOR COSTS FAVORABLE TO ROAD WORK

Labor costs of federal aid projects are in many cases as low as the 1914 level. The price for common labor ranges around 25 and 30 cents in a great majority of states, being somewhat lower in the southern states and going up to nearly 50 cents an hour in the Pacific states.

CONTROLLING THE QUALITY OF MATERIALS IN HIGHWAY CONSTRUCTION

(Continued from Page 184)

may properly be shipped in closely woven canvas bags. The quantity actually required for testing is approximately 5 to 6 lb., and samples should preferably contain from 8 to 10 lb. of material.

Sand samples should consist of about twenty pounds of material and should be obtained by taking small portions of material from various parts of the supply represented and combined to form a test sample. Samples of gravel and crushed stone should be taken in a similar manner, about 30 or 40 lb. of material constituting proper size sample. These samples may be transmitted in canvas bags or tight boxes.

General experience seems to teach us that a great deal of difficulty is usually obtained in securing representative samples of rock from ledges in quarries. As a first consideration rock should preferably be sampled by taking samples from all the different formations within the quarry. In some quarry examinations conducted for the Michigan State Highway Department the speaker has selected as high as 25 or 30 samples to determine the entire range of the material in a given quarry. Samples of ledge rock should consist of about 40 lb. of material larger than 1½ in. in size. At least one piece of material should be approximately 5x5x4 in. to enable cores to be drilled with a diamond drill for the hardness and toughness test. Owing to the nature of the material these samples should preferably be enclosed in tight boxes rather than shipping them in sacks which usually become destroyed or damaged in shipment.

In the cases of paving brick, samples should be taken which accurately represent one lot or shipment of the brick. One sample should be taken to represent the softer brick in each load or shipment, and another sample to represent the hardest brick. In addition, a third sample representing the general average of the material should be selected. Twelve paving bricks should constitute a sample and should be shipped in a box, or crate, preferably in rows with a partition between each six bricks.

Asphalt and tar products, if sampled from tank cars, should preferably be sampled at the time of loading in order to secure truly representative samples. When this is done, portions of the hot material may be taken at intervals during the loading of the car and combined to form the test sample. When sampling from drums or barrels, samples should be taken from a number of drums or barrels in each load or shipment, and combined to form the test sample. In the case of hard products care should be taken to reach the interior of the material and not to include the surface skin, together with any foreign material which may have become adhered thereto. Care should also be taken not to take samples in these cases from material exposed to the weather, and on which free water is standing. The sampling of corrugated metal pipe should preferably be performed at a fabricating plant, but owing to the intermittent shipment of these products, such a procedure is useless unless central purchasing in large quantities is generally practiced. When samples are taken after pipe has arrived on the ground, it is necessary to use a heavy pair of metal shears, or a hacksaw to remove the sample. On account of the work involved, and the danger of damage to the sample, field methods of testing are particularly desirable in the case of this material. A field method of testing these products has already been devised and it is the speaker's opinion that its use will be more generally adopted in the future. The necessity for the use of glassware and chemicals is an objection to carrying such a testing outfit in the field.

In the field testing of materials, these various features in regard to sampling are just as necessary and should be followed out as carefully as when taking samples which are to be sent to a central laboratory.

The testing of materials in the field is naturally confined to those tests for which equipment may readily be manufactured which is comparatively inexpensive and easy to transport, and to those tests which do not require strict conditions of temperature or methods of analysis which can only be carried on in an enclosed room under exacting conditions. As stated before, the testing of such material as Portland cement is a laboratory process. Sand, gravel, and crushed stone may, however, be examined in the field with a good deal of efficiency.

The testing of sand in the field is, of considerably more importance than is generally recognized, both in connection with preliminary tests and with the control of materials from known sources of supply. The tests which are ordinarily conducted on sand are tests to determine cleanness, both as to organic matter and clay, size and grading, and strength in mortar. The latter test is essentially a laboratory test. The size and grading of sand may readily be determined by a set of field screens and sieves. The determination of quantity of clay and silt in sand may readily be made in the field on a volume basis by selecting a sample of the material, mixing it thoroughly, and cutting it down to a size suitable for testing. This small sample is then placed in a graduated glass cylinder together with water, and the whole vigorously agitated without whirling. The per cent of clay and silt, by volume, may

then be determined by measurement of this material which is in the upper part of the cylinder and which may be readily noted by the eye.

It is the speaker's opinion that the determination of organic matter in sand is one of the most important tests that may be applied to this material. The relationship between organic content and decrease in strength of both mortar and concrete has been quite definitely determined, and the low strength of concrete, in many instances, may be traced directly to this particular feature of the sand. Small variations in the properties of Portland cement and other features of aggregates are of insignificant importance if organic matter is present in the sand in any considerable quantity. Fortunately this quality of sand may be determined in the field by a comparatively simple method. The test as it is usually made consists of thoroughly digesting the sand with a 3% solution of sodium hydroxide and observing the resultant color of the liquid above the sand after the mixture has been allowed to stand for a few hours. Then procedure may be briefly described as follows: a 3% solution of sodium hydroxide may be made up by dissolving one ounce of sodium hydroxide (obtainable at any drug store), in enough water to make 32 liquid ounces. Fill a 12-ounce graduated prescription bottle to the 4½ ounce mark with the sand to be tested, add the 3% solution of sodium hydroxide until the volume of the sand and the solution, after shaking, amounts to seven ounces. The mixture should be shaken very thoroughly and allowed to stand for 24 hours. If the solution resulting from this treatment is colorless, or has a light yellowish color, the sand may be considered as practically free from organic impurities and satisfactory for use insofar as this quality is concerned. If, on the other hand, a dark, brown colored solution is obtained, the sand should not be used for concrete aggregate. The time indicated above, of 24 hours, is usually the standard time allowed for settlement of the solution. A very good idea of the character of the sand, however, may be obtained in a much shorter period.

The size and grading of gravel and crushed rock may be obtained very easily by means of a compact set of field screens and sieves.

Occasionally one desires to use a source of water for concrete which appears questionable. While it is true that in this state we seldom encounter unsatisfactory supplies of water, nevertheless, simple tests can be made in doubtful cases to determine whether any supply is objectionable. Strips of red and blue litmus paper (which may be obtained in any drug store) can be used by inserting them in the water for a period of five minutes and noting the color produced. A marked reversal in color indicates the presence of acids or alkalis, and makes further laboratory tests advisable. Laboratory tests usually consist of determination of total solids and quantity of organic matter present, or a comparison of the given water with a water of known satisfactory quality by making standard tests of a sample of cement which is known to be satisfactory.

An important part of the work of field control of materials is in connection with the control of cement concrete entering into either concrete pavements or other concrete strutures suh as bridges, culverts, retaining walls and other similar structures. Due to the large amount of investigative work which has been completed in the last two years, we know a great deal more about the importance of certain features in connection with the manufacture of cement concrete than was the case a few years ago. Time of mixing, method of curing, and the consistency of concrete are now recognized as among the most essential elements affecting the finished product. Time of mixing and method of curing may be easily controlled by the field forces on a construction project. Consistency or the percent of water in concrete is another item which has often been neglected in the past, but which is now receiving more careful attention on the part of both construction organizations, such as contractors, state and municipal forces. We know, beyond a doubt, that a dry concrete is much stronger than a wet concrete, all other conditions being equal. Two methods have been devised for determining the consistency of concrete, only one of which is readily adaptable for use in the field. This method is known as the "slump" test and is conducted by placing concrete, fresh from the mixer, in a metal mold 12 in. high, 8 in. in diameter at the bottom and 4 in. in diameter at the top. This form is placed on a level and preferably a non-absorbent surface, such as a metal plate. The concrete is placed in the open end in approximately three layers, each layer being rodded with a half-inch or five-eighths inch steel rod, preferably pointed at the end. After the form is filled the rod may be used to strike off the concrete level with the top of the form. The form is then carefully removed by raising it in a vertical direction and the distance which the concrete slumps down, or in other words, the difference between twelve inches and the remaining height of the concrete after the form is removed, generally denoted as the "slump," is considered as a measure of the consistency of the material. The entire apparatus for this simple field test can be obtained at a cost of two or three dollars, and if kept properly cleaned, may be used for several seasons.

Tests of the concrete itself may be conducted in a laboratory by taking specimens for tests of compressive strength, wear or cross breaking strength. Probably the most logical test to use is the one involving the cross breaking strength of the material. This test, however, unless laboratory facilities are provided very close to the work is impracticable on account of the necessarily large size of the specimen and the cost of transporting it to the laboratory. Compressive strength tests or tests for wear have generally been utilized to a greater extent.

One of the most important divisions of field testing

is in connection with the operation of bituminous paving plants, but as this subject is to be covered by another speaker at this conference, it will, therefore, not be considered in this discussion.

We have referred to the general plan of laboratory testing. Laboratory testing may be conducted in a central laboratory or in a temporary laboratory connected with or near the manufacturing plants at which the materials are actually produced. Plant testing depends to a great extent upon economy in connection with such procedure. When an oragnization is obtaining a large volume of the products or any given plant it may often be economical to test the product at the plant itself. This method is by far the most convenient one on account of the fact that the quality of materials can usually be determined, and results of tests made known on the job prior to shipment or receipt of the material. In this connection the testing of Portland cement offers one place where plant testing may often be followed economically. The use of aggregates of either sand, gravel or crushed stone on a large scale always makes it desirable to follow up inspection of these materials at their source. As in the case of Portland cement these materials can readily be tested at the plant, and their quality determined prior to shipment. In connection with aggregates it is extremely important that the plant inspector actually inspect the loading of each car of material.

Bituminous materials such as asphalt cement and various tar products may also be properly tested at plants.

Where plant testing is not followed it is desirable, in the case of such materials as Portland cement, asphalt and tar, to station samplers at these plants and have samples taken at the time of shipment, which may be transmitted to a central laboratory and test results obtained as soon as possible after receipt of the samples. Plant samplers in these cases usually consist of men who do this work in addition to some other duties.

In the case of large organizations embracing a rather large area of territory, the establishment of branch laboratories in connection with the main laboratory for testing materials may be followed out economically, and will serve to measurably increase the facilities for the inspection of materials. As an illustration we may take the work of the Michigan State Highway Department, which is scattered over a large area. On account of the fact that the Upper Peninsula is situated so far from the seat of government, and the location of the State laboratory, a branch laboratory located at some city in the Upper Peninsula should work out as a very convenient and necessary arrangement. In addition a branch laboratory for the upper portion of the Lower Peninsula would likewise appear to be desirable. It is quite possible that some such arrangement as this may be worked out in the very near future.

In connection with the examination of materials it may be well to consider one phase of the subject which possibly, in the minds of some of you, is misunderstood at the present time. I refer to the matter of re-testing of materials, which on original test have failed in some one or more particulars, and particularly to the case of Portland cement.

We have already discussed the various properties of Portland cement, dividing them into three classes according to the time necessary to complete tests. These properties may also be divided into two other classes; into one of which we would place those properties which are unchangeable, or very nearly so, in their nature; into the other class we may place those properties of cement which may undergo changes. Under the first classification we have such properties as fineness, and to a limited extent, tensile strength of standard mortar. In the second classification we may place the properties of time of setting and soundness.

When a cement upon original test fails on fineness it does so because of the fact that the material is not ground finely enough to meet the requirements of the standard specifications for size of particles. This property is changeable only to a very slight extent and hence rejections on this property do not warrant retesting of cement unless sampling has been performed in an entirely unsatisfactory and improper manner.

If a cement fails on time of setting or soundness, the user, if he desires to hold the material for a re-test, may properly request that another sample be taken and tested from a certain load or shipment which has previously failed on either or both of these tests. The user, whether a contractor or an organization, whichever the case may be, must necessarily resume all the responsibility for the cost of holding the material for this retest.

In the case of failure of cement due to low tensile strength, a considerable amount of time is necessary in order to complete a second test. Therefore, the matter of economy enters very materially into the question of retesting.

It perhaps may not be out of place to refer to some features in connection with the administration of laboratory work.

On account of the fact that laboratory tests of materials involve shipments of considerable value, it is absolutely essential that the work of testing be carried on by efficient workmen, thoroughly trained, and performing their work according to certain definitely outlined methods. Methods of examination of materials used in highway improvement have been largely the result of work done by organizations such as the U. S. Bureau of Standards, U. S. Bureau of Public Roads, The American Society for Testing Materials, The American Society of Civil Engineers, and other like organizations. At the present time the testing of these various materials has been placed on a rather standard basis, and the work of testing carried on

throughout the country is rapidly becoming more and more standardized, using more uniform methods.

It may readily be seen that extreme accuracy is necessary in the conduct of this work, and that an error due to lack of training or carelessness is very much more serious than often is the case in connection with construction work itself. For this reason the training of men engaged in this work becomes of paramount importance.

In the laboratory of the Michigan State Highway Department, both technical and non-technical men are utilized in the examination of materials, each working in the sphere for which he is particularly fitted. Operators on Portland cement who conduct physical tests only are not permitted in the case of such tests as time of setting, soundness, and tensile strength, to perform routine tests until they have passed through a period of training of from two to three months, working under the direction of experienced men. In many cases this period has actually, on account of existing conditions, been extended to far greater periods. The same is likewise true with reference to other materials and every effort is made, in the cases of failure, to meet certain specification requirements, to carefully ascertain by means of check tests that the results obtained are correct.

The work of a testing laboratory is not confined entirely to the routine testing of materials. Many other duties are part of a laboratory's responsibility. In addition to the routine testing of materials it should be the duty of a laboratory to assist in the proper usage of materials,to aid in the advancement of knowledge of materials, by conducting investigations and work of a research nature, and by assisting in ascertaining and recording the extent and properties of local materials available for use; also by assisting in the preparation of specifications for materials. It should also be the duty of a laboratory to keep a record of materials tested in such a way that at any time the nature of materials entering into any given portion may be quickly and accurately determined. Last, but not least, the utilization of a laboratory in the training of employees in the use of materials is most certainly a valuable and essential part of its work. This function of the laboratory cannot be measured in the number of tests conducted, or quantity of material represented by tests, but is nevertheless a very important service to public organizations.

The cooperation of a central testing laboratory with field forces, involves not only accurate and speedy service on the part of the laboratory, but a willingness to assist field forces in every way possible. The administration of laboratory work along these lines is essential to the efficiency of the organization with which it is connected to insure the obtaining of materials of proper quality, the proper usage of materials on work, and the recording of data of value to the organization it serves.

ROAD WORK WILL RELIEVE UNEMPLOYMENT

Unemployment in Ohio will be materially relieved by the state's highway construction program this year, in the opinion of Highway Director Herrick. The highway department is now bending every effort to award by May 1 all contracts for 1922 road construction and repair work, to insure an early completion this year of every project started.

Plans for the year's construction call for approximately 750 mi. of work, according to Herrick. Of the total mileage planned by the department, contracts have already been awarded for 125¼ mi. Contractors will start on these jobs as soon as the weather permits.

E. C. Blosser, chief engineer for the highway department, estimates that this year's program will give employment to between 35,000 and 40,000 men.

HEARINGS ON FEDERAL AID BILL

Public hearings on the federal bill continuing federal aid were started on March 15 before the House Committee on Roads. According to the bill introduced by Representative Woodruff, $50,000,000 would be made available for the fiscal year starting July 1, $65,000,000 for the next year and $75,000,000 for the following year. This bill also provides for $15,000,000 for road work in national forests during the next three fiscal years.

COST OF PAVING COMPILED ON VARIOUS TYPES OF MATERIAL

Average costs per square yard of various types of paving for country roads have been compiled by the Bureau of Public Roads. The figures cover 68,000,000 sq. yd. of paving constructed with federal aid in all parts of the United States during the period 1916-1921. The costs per square yard are as follows: Sandy-clay, 18 ct.; gravel, 46 ct.; plain and surface-treated macadam, 95 ct.; bituminous macadam, $2.10; bituminous concrete, $2.50; plain cement concrete, $2.57; reinforced cement concrete, $2.74; and brick, $4.10.

These figures cover only the cost of the paving; they do not include the cost of grading, and officials point out that it must not be assumed that roads of the several types can be constructed in any locality at these figures. For example, the cost of bituminous concrete varied from $1.70 in the New England states to $3.13 in the group of states including Kentucky, Tennessee, Mississippi, and Alabama. In one group of states the cost of brick dropped to $2.40. Costs of constructing these types in the various groups of states have been compiled and can be obtained from the bureau.

NEW JERSEY PASSES BOND ISSUE

The New Jersey Legislature on March 17 passed a measure to submit to referendum vote a $40,000,000 highway bond issue. This bill had previously been vetoed by the governor, the legislature passing it over his veto.

MEETINGS

Calendar of Coming Meetings

June 4-6—American Association of Engineers—Annual convention, Salt Lake City, Utah. Secretary, C E. Drayer, Chicago, Ill.

June 13-16—Canadian Good Roads Association—Ninth annual convention, Victoria, B. C. Secretary-treasurer, George A. McNamee, Birks Bldg., Montreal, Canada.

June 26-July 1—American Society for Testing Materials—Twenty-fifth annual meeting, Atlantic City, N. J. Secretary, C. L. Warwick, Engineers' Club Bldg., Philadelphia, Pa.

Oct. 9-13—American Society for Municipal Improvements—Annual convention, Cleveland, O. Secretary, Charles Carroll Brown, Valparaiso, Ind.

THIRD OF TRUCKS OVERLOADED ON MASSACHUSETTS HIGHWAYS

Every third truck on the Hartford-Springfield road and the Boston Post road in Connecticut was loaded beyond the capacity of the truck and the tires, according to a report covering two weeks of investigation on each roadway conducted by the Bureau of Public Roads in cooperation wiht the Connecticut State Highway Department. Overloading occurred on all types of trucks, but was most common on the trucks of 3 to 5 tons capacity. One 3-ton truck was found to have a 62 per cent overload. It was found that 89 per cent of the trucks on regular trucking lines had a total weight of truck and load in excess of 12½ tons, the maximum weight allowed by law in the state.

LOCAL HIGHWAYS BECOMING LONG-HAUL THOROUGHFARES

The United States is now in a period of great highway development, and in a few years many roads which now carry only local traffic originating largely within 5 or 10 mi. of the road will be carrying a large percentage of through traffic, much of it coming from outside the state. This is the opinion of officials of the Bureau of Public Roads, based upon the report of two traffic censuses taken by the bureau in cooperation with the State Highway Department of Connecticut.

The roads selected were part of a fairly complete system of highways. The first census showed an average of 2,907 passenger cars and 281 trucks passing the recording station a day; and the second, 3,832 cars and 511 trucks. Forty-seven per cent of the cars came from without the state. Drivers were questioned as to the length of travel for the day, and results showed average figures of 70 mi. and 52.4 mi. for the two censuses.

The average haul for truck traffic was 47.5 mi., some of them hauling a distance of 250 mi. Officials point out that traffic of this nature has developed in a period of something like 10 years on a road which prior to 1910 carried almost entirely local traffic. It must be concluded, therefore, they say, that roads which are now being improved to form part of through highway routes should be designed to take care of a great deal more than the local traffic or that which is expected to originate locally with the coming of better roads.

WISCONSIN BUYS CEMENT FOR ROADS

The Wisconsin Highway Commission on March 15 decided to accept bids on the entire 4,500,000 barrels of cement needed to construct the 400 mi. of concrete roads planned for the present year at a price of $1.41 net mill.

This means that the cement boycott of eight middle western states which held out for lower bids from cement concerns is broken, A. R. Hirst, highway engineer, said.

Wisconsin had previously accepted a bid of $1.30 net mill on 400,000 barrels of cement from the Marquette company. Other concerns failed to meet the price and in order that the building program contemplated by the state and counties might be carried to completion, it was determined to close contracts for the whole amount needed.

BROOKLYN TO HAVE ASPHALT PLANT

The Board of Estimate of New York City has appropriated $970,000 for the construction of an asphalt plant in the Borough of Brooklyn. This plant will be able to turn out 2,500 sq. yd. of pavement a day.

PERSONAL MENTION

Julian Montgomery has resigned as city engineer of Wichita Falls, Tex.

F. M. Rugely has been appointed city engineer of Wichita Falls, Tex.

W. C. Buetow has been appointed bridge engineer of the Wisconsin State Highway Department.

W. H. Rhodes, Jr., has been appointed maintenance engineer with the Louisiana State Highway Department.

F. C. Lingenfelter, formerly city engineer of Indianapolis, Ind., has opened an office in that city for consulting practice.

A. F. Hartley has been appointed highway engineer for the Cocoa Beach Special Road District, Florida.

GOOD ROADS

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TABLE OF CONTENTS

Widening Narrow Road Surfaces. By O. C. Rollman 191

Construction and Maintenance of Gravel Roads. By C. Coykendall 193

Heavy Trucks and Permanent Highways. By F. J. McCaustland 199

New York State Appropriates $25,000,000 for Road Work 201

Machine Devised to Test Gravel for Road Building 203

Michigan Contracts for Cement 203

More Surplus War Material Available 203

Decade Shows Changes in Types of Road Materials 203

Motor Truck Regulations in Brussels 203

Automotive Conditions in China 204

EDITORIALS:

Status of Highway Engineering 197

Widening Narrow Road Surfaces 197

Gravel Roads 197

Labor Costs Are Declining 197

EQUIPMENT—TRADE—MATERIALS:

*Central Mixing Plant on Road Contract at Colorado Springs 202

Street Paving in Providence in 1921 202

Industrial Railway on Road Contract 202

MEETINGS:

Calendar 204

Good Roads Congress in Argentine 204

Texas Road Builders' Association 204

PERSONAL MENTION 204

*Illustrated Article

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GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

WITH WHICH IS INCORPORATED

THE HIGHWAY CONTRACTOR AND ROAD BUILDER

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Widening Narrow Road Surfaces*

By O. C. ROLLMAN†

The old narrow roads in Wisconsin are composed mostly of gravel, stone and concrete. The construction of the gravel and stone dates back many years. The concrete surfaces date back to 1912.

In the early days when the towns placed the gravel or stone upon our highways it was dumped on the subgrade one load ahead of the other and spread to just about a width of the wheels of a wagon; the idea being that the traffic would spread the material. At the best, this material did not spread over 9 or 10 ft. by the above method.

I can safely say that all gravel or stone surfaces placed before our State Aid Law went into effect, were narrow, outside of a few roads built under the County Aid Law.

In 1912 we started to work under the State Aid Law, and our standard width for gravel or stone surfaces was 9 ft. for single track roads, and 14, 15, 16 and 18 ft. for double track roads.

A great deal of the early state aid work was done by day labor, and the counties, in most cases wanted to produce as much length as possible, and they therefore held to minimum widths of surfaces for several years. The 9 ft. road served its purpose very well during the days of light travel.

Up to the time that the State Trunk Highway Law went into effect we had no real system of roads, and very little was done to build a surface much wider than 9 ft. Our experience in widening old, narrow surfaces dates back to about 1918.

In the spring of 1918 we started to widen some of the old gravel and stone roads that had been placed by the townships. The majority of this work came under what was called gang maintenance. We did not, in all cases, have in mind the widening of this surface, our idea being to level the material and make it a smooth-riding surface. This work required a heavy grader and scarifier, and as we cut into the material that was humped up in the center of the road, the action of the grader widened it somewhat. This widening gave us a feather edge gravel surface, and in many cases the thickness of the surface was reduced to a point where it caused trouble the next year for the reason that it was left thin, but, nevertheless, it made a wonderful improvement in the riding qualities of the road, and I believe I am safe in saying that our early gang maintenance, which was done to widen and level the material dumped by the townships, made improvements which the traveling public did not think possible.

The widening of the gravel and stone surfaces, as mentioned, did not cause any particular trouble and did not require any equipment outside of a grader and scarifier with sufficient power to pull it. A big percentage of this material was oversize, and had to be raked out, picked up and hauled away. I believe we have widened more miles of gravel or stone surfaces by the above method than any other way.

The widening of our old 9 ft. stone or gravel roads that we built under the State Aid Law is done somewhat different. This could not be moved out with a grader on account of the earth shoulders.

The methods used in widening our 9 ft. trench jobs varied as follows:

1. Breaking up the earth shoulder and cutting a new trench with a grader the same thickness as the present surface and filling this trench with new material. In many cases the old material had to be scarified and re-shaped to make the crown uniform throughout.

2. Placing 3 or 4 in. of new material on top of the old surface and spreading it over the shoulder 3 or 4 ft., making the road a 16 or 18 ft. feather edge job.

3. Cutting away the earth shoulder to a point level with the bottom of the present surfacing and scarifying

*Paper presented at Wisconsin Road School.

†Division Engineer, Wisconsin State Highway Department.

the old material and spreading it out to about a 16 ft. bottom course. After this bottom course had compacted somewhat, a new course was added which was composed of finer material, and for that reason it was spread wider than the bottom course in order to give the patrolman the finer material to grade in. This is very important for the reason that in our older surfaces the bottom course, in the majority of cases, would be coarse material, and if this is not kept in and covered with finer material, the patrolman will be handicapped in getting finer material to grade into the center of the road.

The widening of the old gravel and stone roads has not been difficult, and the work in the majority of cases has stood up under present-day traffic very well wherever we used enough good material to build up the road to 8 or 9 in. in thickness.

We had to keep in mind getting a bond with the old material and to see that the crown was not excessive. The matter of crown is very important in the widening work for the reason that the new material added along the edges in most cases will compact and settle more than the center of the road, thereby causing a somewhat dangerous condition to travel. We have made several mistakes in the widening of old surfaces without adding sufficient new material. This caused failure the next spring because there was not thickness enough to carry up. We will continue to widen the stone and gravel surfaces from year to year as traffic becomes heavy.

Some of our old water-bound macadam roads have been re-surfaced and widened in one operation in the following manner: The old stone was scarified and widened to the desired width and used as a base course. This was well rolled, the voids filled, and a 3 in. tar penetration top added. The above method utilized all old material making a first class foundation and gave us, by adding the new top, a very satisfactory road which stood up under heavy traffic.

The widening of our narrow concrete surfaces was started soon after they were laid. Gravel or crushed stone is the material used. To start with this material was added to the earth shoulder a few inches at a time, possibly not over 1 or 2 ft. wide. This was done to get away from the small ruts along the edge of the concrete. As traffic got heavy we had to cut away the earth shoulder and fill it with gravel or stone. Where the gravel or stone was rolled, or compacted by traffic, this method helped the situation somewhat, but we found on heavy traffic roads, the continual crowding away of this material right next to the concrete made a drop of from 1 to 3 in. at this point which made it dangerous when one set of wheels left the concrete surface and turned to get back upon it. The gravel or stone shoulder requires continual maintenance to keep this material at the same elevation as the concrete. The above method was used a great deal for the reason that it did not require much equipment to place it, and the material was available at a short haul in the majority of cases. We find that the crushed stone does not produce any better shoulder than gravel, unless it is surface treated heavy near the edge of the concrete.

The widening of our narrow concrete roads with bituminous macadam has worked out very well, and has the advantage over stone or gravel in that it stays where put. This type of construction gives a smooth surface, and if built right, will not crowd away from the edge of the concrete.

We shouldered a 9 ft. concrete job in Outagamie County in 1920 with tar shoulders. It is as follows:

Tar Penetration Macadam Shoulders on 9 Ft. Concrete Road

1,700 ft. of 9 ft. concrete widened to 18 ft. with 4.5 ft. macadam base on either side covered with 4.5 ft. tar penetration macadam.

Average haul for stone delivered by trucks, 6 mi.

Tar and 15 cu. yd. gravel delivered from Appleton, a distance of 13 mi. (68 bbls.).

Crew consisted of foreman and 6 men.

Equipment: tar kettle, two pouring cans, and steam roller, small tools.

Trench for shoulders, excavated 8 in. deep and 4 ft. wide. Foundation 5½ in. wearing course 2½ in.

520 cu. yd. stone at $4.25 del.	$2210.00
3,400 gal. tar at 20 ct. del.	680.00
Labor (trenching, spreading stone, pouring tar, and rolling)	528.85
Total cost of 1,700 sq. yd.	$3,418.85

Cost per square yard, $2.01.

A. G. Brusewitz, County Highway Commissioner, Outagamie Road and Bridge Commissioner, and Division Engineer Otto Rollman have expressed their satisfaction with the work as it stands.

Widening of Narrow Surfaces on Curves

On our old work we have many right angle turns. These turns have been widened from time to time on the inside with stone or gravel, and we have worked the right angle turn into a curve which has a radius of from 50 to 75 ft. This at the best is sharp, and is not taking care of the fast traffic. In the majority of cases we have stopped this widening, and have started to re-locate the road putting in curves that have a radius of 300 ft. or more, and building the new surface a minimum width of 20 ft. on the secondary roads, and a minimum width of 24 ft. on the main lines of traffic. The widening of our concrete roads at right angle turns has in some cases been a case of paving the intersection. This is especially true where two important highways cross. We believe the tendency in the future will be to swing in easy curves getting away from the road intersection altogether, than to be continually widening at these points. The widening of concrete surfaces at right angle turns or

road intersections becomes expensive on account of the number of square yards of concrete that we place from time to time. A relocation in many cases will shorten the distance and will not require the number of square yards of pavement.

Narrow Concrete Roads Widened With Concrete

Wayne County, Michigan, has the following to say in their fifteenth annual report:

The construction of concrete shoulders for widening narrow concrete roads put down during the early period of Wayne County's highway building is the means we are using to secure relief from the excessive cost of maintaining macadam, gravel and penetration macadam shoulders, and to place these highways in condition efficiently to carry our rapidly multiplying traffic. The report states that they are using caterpillar tractors to plow and grade out the old earth and stone shoulders. Men follow with sledges and break off the edges of the old 12 ft. concrete road making it rough and uneven so as to secure a firm bond with the new concrete. Industrial railroad tracks are laid the full length of the road leaving 9 or 10 ft. of the old concrete free for travel, which is maintained at all times during construction.

The concrete mixing is done at a central plant where the materials are hauled by motor truck and mixed in a stationary concrete mixer. The concrete is run into side dump industrial cars and hauled out on the job by a gasoline locomotive and dumped directly from the car onto the prepared subgrade and forms.

Our high standard of construction prevails on this work as though it were a new road. The concrete extension is built 9 in. thick. The expansion joints are used matching up the old expansion joints in the road. The concrete is finished up carefully by hand so as to get a smooth, even surface when completed.

The cost of this work has been slightly greater per square yard than as though we were building a new road, but considering the fact that we are maintaining the traffic during construction, having considerable shouldering and ditching work to do in order to finish up the draining work, our cost of $3.50 per square yard has not, in our opinion, been excessive.

This widening is a forerunner of what extensions will be done on every mile of concrete road in Wayne County of a lesser width than 18 ft. When the task of improving the roads in Wayne County was begun, Detroit had a population of only 300,000. At that time the demand was for mileage and in view of the comparatively light traffic of that day, we built many miles of concrete roads from 12 to 16 ft. wide. Now that the population of Detroit has passed the million mark and the city has become the automobile and motor truck center of the world, travel on these roads has so greatly increased that the cost of maintaining macadam shoulders—mostly of the penetration type—necessitates the adoption of another policy. Fortunately, it is entirely practical to widen our roads with concrete and still conserve the original investment in the narrow slabs.

We have given a great deal of attention to planning for the future; and we expect to continue to widen as rapidly as possible, all main trunk lines to at least 24 ft., while secondary roads will be paved to perhaps 20 ft. At present we are building some 24 ft. road slabs, and have tentatively laid out several heavy-duty radial roads that are to have a right-of-way of 100 ft. and a concrete pavement 36 ft. wide.

Construction and Maintenance of Gravel Roads*

By C. COYKENDALL†

In considering the construction and maintenance of gravel roads, or for that matter, of any other type of road improvement, it is well to keep in mind what we as highway engineers are attempting to accomplish, namely, the development and improvement of a highway transportation system adequate to the needs of the traffic using this system. The situation in a way can be likened to our railway transportation system with its comparatively limited mileage of main line roads supplemented by a network of secondary lines converging into and feeding the main line system. In our highway system we have a comparatively limited mileage of primary roads, a more extensive mileage of important secondary roads, and, especially is this true in the Mississippi Valley region, a large mileage of secondary roads which are of importance only as local or community roads. Consequently, in considering any particular type of improvement, we must give consideration to the part of the system on which this improvement is proposed, and the probable ultimate use to which the highway will be put.

It is not likely that for a number of years to come it will be found necessary or economical to hard surface more than a very limited percentage of our total mileage of rural highways; probably in most portions of the Mississippi Valley, not to exceed five to eight per cent. There is an insistent demand on the part of road users, however, to have all highways which must be used placed in serviceable condition. It will therefore be seen that the improvement of the 92 to 95 per cent. of the total road mileage constituting our

*Paper presented at annual meeting of the Highway Engineers' Association of Missouri.

†Assistant Chief Engineer, Iowa State Highway Department.

secondary road systems is a problem deserving at least equal consideration with the problem of improving the 5 to 8 per cent. of the total mileage which falls in our primary road system.

The type of improvement most generally practical for secondary road systems is a gravel surfacing or sand-clay surfacing. It has been found during the past ten years that this type of improvement is in general more economical than waterbound macadam and more cheaply maintained under modern traffic. It therefore follows that there is probably no problem deserving of more thoughtful consideration on the part of highway engineers than proper methods of constructing and maintaining gravel and sand-clay roads.

In this discussion no fine distinction will be made between gravel and sand-clay construction. Satisfactory results can be obtained with either gravel or sand-clay construction if available material is used intelligently. Given ideal materials, the construction of any type of road is not a difficult problem. It requires a higher degree of engineering ability to get satisfactory results from the most available sources of material even though such materials may be generally regarded as of inferior quality, than to require ideal materials without consideration as to the availability of such materials, and the resulting construction costs.

We, as highway engineers, naturally delight in constructing high type roads. Is it not a fact, however, that it is a more serious mistake, considering both the engineering features and the economics in the situation, to build a pavement on a road where the travel can economically be taken care of with some cheaper type of construction, than to build a cheaper type of construction on a road where the traffic requirements really demand pavement? In the first instance, we have tied up more of our capital than the amount of traffic served will justify, and the road is not a paying proposition. In the second instance, we have erred on the side of economy, with the result that the traffic will not be so well served, but probably the service given will be no more costly than had a pavement been constructed.

It is extremely difficult to determine where the dividing line between the construction of pavement and the construction of gravel roads should be drawn. There are a number of factors that must be taken into consideration in making this determination. Perhaps it would be well to enumerate some of these factors.

First, and primarily, the amount of traffic which must be handled, either present traffic which the highway is carrying, or the traffic that we can reasonably anticipate will be handled as soon as the road is completed. No one can state with any certainty the exact number of vehicles which a gravel road will handle in a satisfactory manner. All of us know from our experience that there are roads on which the traffic cannot be satisfactorily taken care of on such a surface. Likewise, we all know from our experience that there are roads of secondary importance where a gravel surface serves every need of the traffic. Between these two points, however, there are many situations which are not so easily classified.

During 1919 and 1920, the State of Iowa in connection with the submission of federal aid projects did a considerable amount of traffic census work. Some of the roads on which a traffic census was taken had failed to satisfactorily take care of traffic as gravel roads. The traffic count showed that on the road south from Spirit Lake, which is perhaps the most popular summer resort in Iowa, there was an average daily traffic of approximately 915 vehicles. This road could not be satisfactorily maintained as a gravel road under this traffic. On the Jefferson Highwy north from Des Moines the traffic count showed an average daily traffic of approximately 800 vehicles. It has been found that this road could not be satisfactorily maintained either as a gravel road or with a cinder surfacing. On a project in Howard County, which is some distance from the centers of population and carries only the ordinary county seat to county seat traffic, and a very limited amount of through traffic, the traffic count showed an average daily traffic of 238 vehicles. This road has been completed as a gravel surfacing project and is taking care of the traffic in a very satisfactory manner. The same is true of a project in Chickasaw County where the traffic count showed an average daily traffic of 216 vehicles.

We have reached the conclusion in Iowa that where the daily traffic is not in excess of 500 vehicles per day, we can quite successfully construct and maintain a gravel surface. Where the traffic is in excess of this amount, however, maintenance costs mount rapidly and we are unable to give traffic service that is comparable to the service given by a properly constructed and maintained paved road.

Second, availability of materials for gravel road construction and maintenance; also availability of materials for paved road construction and maintenance. Availability of materials determines in a large measure the economical type of improvement on any road. Where a good quality of gravel is available locally for gravel surfacing work, it is economical to construct and maintain gravel roads under conditions where it would not be economical if all such material for construction and maintenance had to be transported a long distance by rail, thereby greatly increasing the cost of construction and maintenance work. The real measure of the value of any type of road is the cost per ton mile or vehicle mile to the users of the highway. In determining this cost the availability of materials is an important factor.

Third, the relative usability of the two types of road. In considering usability we must take into account tractive resistance, satisfaction and convenience to the users of the road, and the safety of the road. Often we are justified in paving a road that can quite econ-

omically be taken care of by some cheaper type of construction, from a consideration of these factors alone. You have all had experience in driving over a gravel road where the surface was in good condition but the dust was so bad that it constituted not only a nuisance, but an actual menace to traffic. You have also probably seen gravel roads, especially during a long continued dry spell, where the loose gravel which had accumulated at the sides and on the shoulders constituted a real menace to travel, particularly at night when meeting or passing other vehicles.

Experiments carried on by the Engineering Experiment Station at Ames, during the past year show that for truck traffic, a good concrete or brick surface requires a 20 to 30 per cent. less gasoline consumption per ton mile than is required for a road with a good gravel surface. Similar conclusions were reached in a series of tests carried on a few years ago by Professor A. N. Johnson, now with the University of Maryland. Hence, it appears that on account of less surface resistance, actual operating costs to motor vehicle users are less on a good paved road than on a good gravel road, and this with other factors that are measures of the usability of a road are worthy of consideration in determining the proper type of improvement.

Fourth, the length of time that must necessarily elapse before a road can be paved. It is often economical and expedient to gravel surface a road where traffic conditions will justify pavement in order to provide the traveling public with a usable road until such time as the pavement can be constructed. The building of a system of paved highways including five to ten thousand miles is no small undertaking, even after the necessary legislative action has been taken and the necessary funds for financing the program have been provided. It takes time to develop an engineering organization capable of properly handling a large paving program. It takes time to develop sources of material sufficient to take care of a large paving program. It takes time to develop a contracting organization to do the actual work. From our experience during the past two or three years, during which time a large paving program has been under way, we can appreciate the fact tht few states are organized to build more than a few hundred miles of pavement each year. The states of Illinois and Pennsylvania are probably carrying on the largest paving program that any state has up to the present time attempted. Yet neither of these states have in any one year constructed one thousand miles of paved road. The demand of the public is for "usable roads now." Consequently in many instances we are justified in producing a large mileage of relatively cheap road which will give road users service during the time that must necessarily elapse before a large mileage of paved roads can be produced.

Fifth, legislative machinery for building various types of road. This is really the meat of the whole situation. We cannot build roads except as we are authorized to do so by our state legislatures, and are provided with the necessary funds. Consequently in states where we are not authorized to build paved roads and in which funds for financing this type have not been provided, we must build the best type of road that has been authorized and for which funds have been made available.

Referring again to the situation in Iowa, we cannot build paved roads in any county in Iowa until the voters of that county have authorized the general policy of hard surfacing the primary road system of that county. If we are to make any material progress in those counties that have authorized the paving of the primary road system, a bond issue must also have been authorized. Consequently, in Iowa we are not in position, in all cases, to build the type of road which should be built from a consideration of the needs of traffic, nor is this restriction peculiar to Iowa alone.

This discussion up to this time has dealt only with factors covering the selection of the type of improvement. We will now assume that we have a road which is to be gravel surfaced, and will give consideration to the details of construction.

Alignment, Grade and Cross Section

In gravel surfacing primary roads the same consideration as to alignment, grade and cross section applies as in the case of paving. There are many miles of our trunk line or primary road system that should probably be gravel surfaced before they are paved. Without doubt, however, the time is not far distant when this mileage should and must be paved. Consequently in building a gravel road we should attempt to determine upon a location and prepare a design as to grade, drainage structures, and cross section, which will prove satisfactory later on when the road is to be paved. It is quite generally recognized that the maximum grade for primary roads should not exceed six per cent., and should be made as much less than six per cent. as topographical conditions will justify. Horizontal curves should be held as closely as possible to not to exceed ten degrees. Right angle turns should be rounded with a curve of not less than 200 ft. radius, while a 300 ft. minimum requirement is better. In so far as it is at all possible, the element of danger at railway crossings should be eliminated, either by grade separation or relocations of the highway which will eliminate the crossings entirely. The cross section should provide a minimum from twenty-eight to thirty foot width between shoulders with ditches at least two feet below the shoulder line, and four to six feet out from the shoulder line. A flat bottom ditch at least two feet in width should be provided and back slopes made with whatever slope is required to prevent the ditches from filling.

On secondary roads less stringent requirements can be laid down as to grade, alignment and cross section. Grades and alignment should be the best possible to secure giving due consideration to the amount of traf-

fic the road must carry. The cross section will vary between twenty and thirty feet, the limits depending upon the importance of the road, with substantially the same requirements as to ditches and back slopes outlined above for primary roads.

Drainage

Thorough subdrainage is absolutely necessary to successful gravel road construction and maintenance. It is probably even more essential on this type of construction than on pavement, inasmuch as the road surface itself has so much less inherent strength. Subdrainage can be secured either by the use of tile or by the construction of a grade which will bring the surface of the road well above the ground water limits. In all cases the surface of the road should be at least 22 ft. above the ground water level, and as much more than this as it is practical to secure. It is generally conceded by everyone at all interested in the road program in Iowa that thorough drainage is a primary essential to successful road construction. The people of Iowa are probably more nearly in accord on this point than on any other point in connection with our road building program. In the level sections of the state where natural drainage conditions are poor we ordinarily use more than a mile of tile drain per mile of road. During the past construction season, we laid more than one thousand miles of tile drain.

Material Specifications

Specifications for material to be used for gravel road construction should be broad enough to admit any graveling material which by intelligent application can be successfully used in road construction. All states are not in accord with this but as stated heretofore, we believe that it is necessary to utilize to the fullest advantage the materials that are available. The maximum size of stone should not exceed 1½ in. If this limit is changed, we would recommend decreasing it rather than increasing it. The amount of binder which the material may contain is extremely variable. As a general proposition the less binder that is used, the better. There are comparatively few instances where it is justifiable to haul binder for any considerable distance, inasmuch as substantially the same results can be secured by incorporating the loam, clay, or gumbo, or the road into the surface as binder.

Amount of Material Per Mile

The amount of material required per mile of road varies, of course, with the type of road being improved. Ordinarily between one thousand and two thousand cubic yards per mile is enough. More material can be added from time to time as a maintenance measure. Consequently, it is not advisable to place as a construction measure so much material that it is a serious problem to traffic to properly campact the material.

Handling of Construction Work

Gravel road construction work is very readily handled as a contract proposition if the specifications are properly drawn. The construction of the grade and the installation of the necessary drainage structures and tile drainage should not be tied up to the same contract as the gravel surfacing. Neither should maintenance by the contractor over any considerable period of time be required. The items included in the contract should be as few and as definite as possible. In our Iowa specifications the contractor bids on the following items: Stripping gravel pits, shaping preparatory to receiving the gravel, loading the gravel at the pit and hauling it one mile and spreading, and additional half-mile units of haul. The stripping of pits is on a yardage basis with a specified amount of work to be done. It has been found economical to thoroughly prospect the source of supply before contracts are awarded for gravel surfacing work. From these investigations it is possible to specify with reasonable accuracy the amount of stripping that will be required, also whether or not the material must be screened and oversized material crushed. In the average deposit where there is not a large amount of oversized material, the price bid per cubic yard for loading includes the removal of oversized material at the pit. All hauls of less than one mile in length are included in the price bid per cubic yard for loading at the pit, as is also the spreading of the material upon the subgrade. When the haul exceeds one mile and is less than one and one-half miles the price bid fo reach additional half mile haul is added to the unit price for loading. Similarly for each additional half mile that must be hauled the unit bid is proportionately increased. This method has been found more satisfactory and less confusing to contractors than bids based on average yard mile hauls.

Preparation of Subgrade

Before the gravel is dumped upon the road the subgrade should be flat and smooth. The gravel should then be dumped either on the shoulders or in the center, depending upon the time of year that the work is being done, and then spread the full width of the road. The material in the center should be spread thinly enough that traffic can travel down the center of the highway without serious inconvenience, immediately after spreading operations have been completed. We have not found the use of a roller practical in gravel road construction. Our most satisfactory results are secured by allowing the gravel to be compacted by the traffic, under continuous and intelligent maintenance. By spreading the gravel so thin that traffic is forced to the center, the shoulder lines are not destroyed nor is that the element of danger to traffic introduced that is present when the gravel is windrowed down the center and traffic is forced to the shoulder line. As the center becomes compacted under traffic, loose material from the shoulders is worked toward the center of the road and the road

(Continued on page 198)

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

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Articles by road builders are solicited. They should be short and, if possible, accompanied by photographs. Those accepted will be paid for at current rates.

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STATUS OF HIGHWAY ENGINEERING

"There is probably not a single engineer in the United States who could lay out a rational system of highways," a federal engineer is reported to have stated to James C. Collins, the writer of an article on highways and sundry other things which appeared in a recent issue of the "Saturday Evening Post." "There is plenty of money for improving highways," Mr. Collins alleges this engineer to have said. "We spend hundreds of millions every year. I'll tell you the real limiting factor: It is men trained to plan and build highways on a scale in keeping with the enormous growth which is coming in motor traffic. Plenty of engineers can build good roads, but we lack creative designers of highway systems. Only three or four colleges in the United States have real highway construction courses. One of our first tasks is to put highway engineering into the imagination of the young fellow going to college, as a career and as an intensely interesting new technical field."

This statement certainly does not flatter the highway engineering profession nor the schools which include instruction in highway engineering in their curricula. One might expect such a statement from a professional writer, but hardly from an engineer engaged in highway work.

There are as big men in the highway field as there are big men in other engineering fields. The highway engineering courses in our schools are as thorough and as comprehensive as are other engineering courses. To say, in effect, that millions of dollars are being spent on road construction in this country by incapable, illy-trained men is absolutely false.

Highway improvement in this country is attended by many complicated problems. The highway engineer can not take a map and mark out the roads to be improved, as did the Czar of Russia lay out the railroad through Siberia.

WIDENING NARROW ROAD SURFACES

With the increase in motor traffic many of the roads built for horse-drawn traffic proved too narrow to care for the new type of traffic. Accordingly, many states have been obliged to widen narrow gravel, macadam and concrete pavements. Gravel and stone roads do not present any considerable difficulty in widening. As pointed out in an article elsewhere in this issue, Wisconsin has widened a considerable mileage of this type of roads with graders and scarifiers. In the case of concrete roads, Wisconsin finds that gravel shoulders are as satisfactory as crushed stone shoulders. However, bituminous macadam shoulders have been found more satisfactory in widening concrete pavements in that a smooth surface is obtained and the material doesnot crowd away from the concrete.

GRAVEL ROADS

In point of mileage, gravel roads are the most important type of road construction in this country. "It is not likely that for a number of years to come that it will be found necessary or economical to hard surface more than a very limited percentage of our total mileage of rural highways." says C. Coykendall, Assistant Chief Engineer of the Iowa State Highway Department, in an article elsewhere in this issue. "We have reached the conclusion in Iowa that where the daily traffic is not in excess of 500 vehicles per day, we can quite successfully construct and maintain a gravel surface."

LABOR COSTS ARE DECLINING

Labor prices for road work still continue gradually to decline, according to figures collected by the Bureau of Public Roads from road jobs in all parts of the country. Prices paid for common labor in February decreased slightly more than one cent per hour below those paid in January, the average prices for the whole country being 29 and 28 ct. an hour, respectively, in the two months. Prices paid for skilled labor also showed a general decline.

In February the price of common labor ranged from 13 to 20 ct. an hour in the Southern States, 23 to 30 ct. an hour in the Middle Western States, and around 45 ct. an hour in the Pacific States. The prices of teams without drivers ranged from 24 to 42 cts. an hour.

CONSTRUCTION AND MAINTENANCE OF GRAVEL ROADS

(Continued from page 196)

gradually assumes the cross section intended, that is, a thickness of five to seven inches at the center line shouldering out to a feather edge near the shoulder line. It is often found during the process of compacting the gravel that the material used is deficient in binding qualities. Usually this difficulty can be remedied by harrowing, plowing, or otherwise mixing the material of the subgrade into the surfacing. It is believed advisable, however, to exercise considerable discretion as to the amount of binder used. Traffic should not be seriously inconvenienced by being forced to travel for a long period over a loose gravel road, but if some patience is exercised both by the engineer in charge of the work and those using the road, it will be found that a more successful road will result from a sparing use of binder.

Maintenance

Under the construction specifications which have been recommended, it is very difficult to state where construction stops and maintenance work begins. As a matter of fact it is recommended that the maintenance organization take over the road as soon as the gravel has been placed on the subgrade, spread once and thoroughly mixed. The success of any gravel road is dependent very largely on the maintenance. Consequently, as soon as the gravel has been placed, a well organized maintenance crew should be in position to take the road and give it proper attention through the very important stage that it is being compacted by traffic.

For the gravel roads which we can economically build from material available in Iowa, maintenance by a bituminous mat coat or by the application of bituminous materials is not recommended. Many of our materials have too large a percentage of fine material to make this system of maintenance successful. In fact, representatives of commercial interests primarily engaged in the manufacture of bituminous road materials do not recommend the use of such materials on many of the gravel roads in Iowa. This discussion will be limited to maintenance of gravel roads by methods other than by the use of bituminous materials without in any way entering into the merits of the use of such materials where a different type of gravel is available for the construction work.

Gravel road maintenance divides itself quite logically into two operations: First, the maintenance of material placed during construction, and second, maintenance by adding additional material. Both operations are necessary. We must expect to renew from time to time the material which is lost either by the action of the elements or by gradually being forced into the subgrade. On our most heavily traveled gravel roads in Iowa the annual replacement of surfacing material is from three to five hundred yards per mile per year.

For keeping gravel road sufaces in good condition the patrol system of maintenance is strongly recommended; that is, a patrolman equipped with a patrol blade grader and other incidental tools should have full charge of the maintenance of a certain section of gravel road. The length of this section is dependent upon the importance of the road and the amount of traffic which it carries. For the heavily traveled roads ordinarily five to six miles is the maximum which a patrolman can take care of. The surface of a traveled gravel road requires constant attention, regardless of weather conditions. The best results in filling chuck holes that develop are secured after it rains, but the prevention of the development of chuck holes is dependent largely on the care the road receives during the dry weather periods. If a film of loose material can be kept on the surface of the road, it will be found that this film of material really bears the brunt of the traffic and prevents raveling of the surface of the road. Naturally, if a film of loose material is to be kept spread over the surface, continual attention on the part of the patrolman is required, as traffic tends to whip this loose material to the center and to the shoulder lines.

The efforts of the patrolman must from time to time be supplemented by what is ordinarily styled gang maintenance. The patrolman is not equipped to do heavy work such as opening ditches or building up the shoulders. It will be found on a heavily traveled road that from time to time an accumulation of loose material has taken place on shoulders and that it is very difficult to get this loose material to pack in the center of the road. In those cases it is often necessary to really reconstruct the road; that is, the loose material that has accumulated on the shoulders should be forced to the center of the road, the shoulders built up from material taken from the ditches, and the gravel respread from shoulder line to shoulder line. For this work, a 12-ft. blade grader drawn by a tractor is very effective. It will be found in this operation that the material taken from the ditches acts as new binder, and that better success will be had in getting the gravel compacted. Quite often this process should be supplemented by the addition of a maintenance course of material. In fact, this process practically always should precede the adding of a maintenance course of material.

Gravel Maintenance of Earth Roads

We have experimented in Iowa during the past year with a so-called gravel maintenance of earth roads. That is, an earth road that has been properly graded and drained is given a very light surfacing of gravel—approximately five hundred cubic yards per mile. We have not considered that with this much material we have been building gravel roads, but we have been making earth roads much more usable for eleven months at least out of every year. The addition of the gravel to the top soil of the road makes the gumbo

soil or heavy clay soil much more easily maintained under heavy traffic. It also makes the surface of the road impervious to ordinary summer rains.

The cost of this kind of maintenance where gravel is locally available, is not heavy, and it is expected that on roads where a five hundred yard maintenance course has been placed this year, an additional five hundred yards will be placed during the coming year, and in time we are quite apt to have "maintained" an earth road into a gravel road. Material used for this kind of work should all pass a screen with one inch openings. We are much interested in the possibilities of this type of road work and expect to try it on quite a considerable mileage during 1922.

In conclusion we have these points which should be emphasized in connection with the construction and maintenance of gravel roads:

First, do not lose sight of the importance of this type of construction. For years to come this type will undoubtedly constitute the greatest percentage of the surfaced roads that are built.

Second, make the maximum use of available materials. Have your specifications as to materials flexible enough to allow the use of any gravely material which with intelligent construction and maintenance methods can be advantageously used for gravel road construction.

Third, draw your specifications in such a manner that the construction of gravel roads is a readily contractable proposition. Do not require the construction contractor to do a lot of maintenance work for which he has neither equipment nor the experienced organization so necessary for satisfactory gravel road maintenance.

Fourth, do not expect satisfactory results from any gravel road unless thorough and systematic maintenance can be given. No gravel road is any better than the maintenance it receives.

Heavy Trucks and Permanent Highways*

By E. J. McCAUSTLAND†

What is meant when the term "permanent highways" is used? The phrase is one frequently heard, but its meaning is not well established, since we find it used to convey quite different ideas under different conditions when used by different individuals. In fact, the term has become a mere figure of speech, since we know that no highway so far constructed has been found to be absolutely permanent; furthermore, if compared with other engineering constructions, a little consideration will show that we can not hope to attain anything more than a certain degree of permanence even with the best materials obtainable under any ordinary conditions of traffic. We can, however, choose for road making purposes those materials best suited to the traffic the finished way must bear so that depreciation charges may be kept to a minimum, at the same time maintaining a standard of one hundred per cent efficiency in the roadway at all times.

Some of the Elements of Permanency

The permanency in service of a highway, as an instrument functioning in the problems of transportation, is limited by the stability of the foundation under repeated loadings and the durability of the wearing surface under the attrition of traffic and the effects of weathering. These are independent elements affecting permanency, although it is to be noted that the relative stability of the foundation affects to a marked degree the durability of the wearing surface. That is, a weakness in the foundation directly shortens the life of the wearing surface.

The foundation should be designed to carry, without injury, the greatest load that may be brought upon it. If the foundation yields even to a slight degree it is permanently damaged and an incipient failure of the wearing surface at once occurs. If the foundation actually fails, the road must be rebuilt so that it becomes practically a new struture. It follows therefore that, in case funds are limited, maximum effectiveness must be sought from all funds used in the construction of a foundation. That is, the foundation must be designed to carry the maximum load which may be allowed to come on the highway and legal restrictions should intervene to limit loads to that for which its foundation was originally designed.

Ours is practically a new country, and, as compared with the amazing development of the railways as a means of transportation of men and goods, highway development has been very slow. Even at the present time our rural and urban communities develop much more enthusiasm over the prospect of a railway or inter-urban electric line than they do over a newly-projected highway, in spite of the fact that ultimately they pay for all three.

It must be remembered that in the older countries, particularly in England and on the European Continent, the foundations for the present magnificent system of highways have been in process of formation for centuries. In this country the situation is entirely different. The railways have made possible the spread of the population over great areas and thus intensified and made difficult the problem of highway building. We have had neither the time nor the occasion to build up foundations for present lines of highway. For our

*Paper presented at annual meeting of the Highway Engineers' Association of Missouri.

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present needs we must build from the very bottom and our sub-foundations must be laid in the fertile soils of our vast areas of farming lands. It is not a figure of speech to say our problem is to "get out of the mud" while the current problem in the older countries is much simplified by a more gradual development of its territories over a period measured in centuries.

The second point which relates to the permanency of a highway is bound up in the character and quality of its wearing surface in relation to the traffic it must bear. If the foundation is good this wearing surface may be renewed again and again, and in the better types of development this method is used to maintain a high degree of efficiency in the highway as a unit in effecting transportation. While a satisfactory foundation may serve to support an indefinite number of wearing surfaces, the type and character of the material used in the construction of such wearing surfaces must be carefully chosen in view of numerous and complex variables such as present and probable future traffic, first cost of construction, annual depreciation and cost of repairs, as well as the ease and promptness of renewal. The last item particularly should not be overlooked since interruption of traffic may become very costly.

From what has preceded, it appears that the failure of highways to sustain the traffic imposed may always be charged to one or two causes. Either a faulty construction of foundation, or an improper choice of surfacing material. The foundation may fail on account of unstable soil conditions, bad drainage, frost upheaval, or overloading. All of these causes are subject to investigation and susceptible to prevention within reasonable limits of cost. The skilled engineer may, therefore, design a road and its foundation for any probable condition of loading. It remains to devise and enforce regulations which shall prevent overloading, and this point will be discussed later.

The problem is not so simple when it comes to a choice of material for the wearing surface. It is always difficult to predict accurately the effect of traffic on a particular type of road surface. Much depends upon the character of vehicles used as regards method of propulsion and upon the magnitude of the load carried. These variables as well as the speed of traffic, width and type of tires and roughness of road surface may not be reduced to a formula and only experienced judgment is of value in reaching a final decision.

Much has been written, and many investigations have been made regarding the effect of heavy trucks on road surface and on road foundations, but much is yet to be determined. It is found that the character of the vehicle and the relation between the sprung and unsprung weight which it carries has an important bearing on its effect as a destructive agent. These investigations are still being conducted and engineers are coming every day into possession of more and more reliable information which will help in forming correct judgment.

General Policy

The general practice at the present time in a program of highway building is to study present conditions as relates to character and volume of traffic, make some estimate of future development regarding possible change in these particulars, and with this as a basis choose type and character of improvement; when a road so constructed is destroyed, rebuild to a higher standard and then again repeat the cycle of construction and destruction. Certainly a saner and more scientific plan of procedure would be to first make a careful study and estimate of future development from present conditions in reference to growth and character of traffic and to fix in advance the type nad capacity of the vehicles that will be allowed to carry the traffic over the designated highway. When these points have been decided upon, then design the road, having in view these fixed conditions, both as to foundation and wearing surface, and finally provide for adequate maintenance. The former method is clearly unscientific and a mere makeshift, while the latter gives opportunity for the application of experienced engineering judgment.

To insure protection against wanton destruction of highways by excessively heavy trucks drastic legislation is needed. In "48 states there are no less than 17 different bases or combinations by which" an attempt is made to secure such protection. However, this legislation generally takes the form of exacting fees based upon some one or more of the 17 items above mentioned. These are: horsepower, carrying capacity, weight (vehicle only), gross weight (vehicle and load), cost of vehicle, piston displacement, total tire width, weight of chassis, flat rate per vehicle, horsepower plus gross weight, horsepower plus vehicle weight, horsepower plus cost, horsepower plus capacity, weight plus cost, weight plus capacity, weight plus horsepower plus cost, weight plus horsepower plus cost plus capacity. Of the above items the Uniform Vehicle Law recommends horsepower plus gross weight.

The main purpose of these state laws apparently is to insure some return in fees from truck owners for the use of the roads. Some states limit loads, but in very few instances is there any attempt to classify roads on the basis of carrying capacity and refuse the use of any road to excessive traffic. To continue the attempt to build roads to carry any load that the truck owner may see fit to impose is to court financial ruin and to arouse bitter opposition on the part of the ordinary taxpayer.

Justification for the Recommended Policy

In the first place, trucking as such, is a business venture maintained and conducted primarily to return profits to owners of trucks. It is a business also which is to some extent, in competition with the rail-

ways. In order to make possible a profitable business of trucking the public provides at great expense the way over which the vehicles move and this is done at no cost to the truck owner. It is true, the public may receive some benefits in reduced freight and passenger rates, but even if these reductions are sufficint to absorb the initial expense of highway construction, such advantage is not evenly distributed, and becomes less so in case of rebuilding. Good engineering practice can not justify the wastes that now exist in and are inseparable from the custom of building roads for a traffic which is too destructive of them and which soon demands further expenditure.

It is pointed out in an article on motor vehicle regulation in an engineering periodical that, "At the end of the year 1920 the U. S. Bureau of Public Roads reports a registration of 852,362 motor trucks and commercial vehicles. There were produced during 1920, according to the National Automobile Chamber of Commerce 322,039 motor trucks as shown in the following table:

Capacity Tons	Number	Percent of Total
¾	61,187	19
1	164,240	51
1½	35,424	11
2	25,763	8
2½	12,871	14
3½	12,893	4
5	6,441	2
Over 5	3,220	1
Total	322,039	100

It is to be noted that the 1-ton truck is the prevalent size, constituting 51 per cent of the 1920 production; that the 5-on truck constitutes only 2 per cent of the total output; and that trucks exceeding a capacity of 5 tons represent only one per cent. While the number of large-capacity trucks is comparatively small, costly damages to road surfaces can be done by only a few of these large units."

As to the future trend of laws governing truck traffic it is impossible to predict; I will venture a suggestion, however, that will challenge some consideration; laws are but an expression of the crystallized and formulated sense of right and justice on the part of the people; fair-mindedness and a comprehensive view of the whole problem of transportation is demanded of road builders, the public and the vehicle manufacturer and user; cooperation must be the key-note, but no co-operative agreement can be hoped for until all parties in the case are enabled to see the problem from the opint of view of his fellow as well as from his own. I believe the tendency in the near future will be toward more uniform regulating laws throughout the United States and toward a more rational basis upon which to formulate such laws. Truck builders and operators are helpless without roads; roads built ready for traffic are useless without vehicles; and the public depends upon both for service. Let the slogan be,—"Get together."

NEW YORK STATE APPROPRIATES $25,000,000 FOR ROAD WORK

With the three highway appropriations signed by Governor Miller on March 24, the total amount of money available for highway purposes in New York State amounts to $25,406,215.40.

By making a second appropriation for the construction of rural post roads and reappropriating certain unexpended balances, it was possible to reduce the measure originally passed as chapter 40 of the laws of 1922, providing for the maintenance and repair of state and county highways from $7,500,000 to $6,150,000. The total is far in excess of any amount made available in any previous year since the war for highway purposes. The grand total is made up as follows:

Reappropriations	
Chapter 6, laws 1922, Highway Improvement unexpended balance	$351,103.76
Chapter 7, laws 1922, Highway Improvement unexpended balance	575,853.59
Chapter 9, laws 1922, Highway Improvement unexpended balance	249,378.86
Total reappropriations	$1,176.236.21
Chapter 8, laws 1922, Rural post highways, U. S. share appropriated by state in first instance 1st appropriation	$4,971,893.11
Chapter 11, laws 1922, State's share rural post roads	$5,500,000.00
Chapter 238, laws 1922, rural post highways, U. S. share appropriated by state in first instance, 2nd appropriation	1,232,149.32
Chapter 239, State's share, 2nd appropriation	1,250,000.00
Total rural post roads	$12,954,042.43
General Reappropriations	
Chapter 10, laws 1922, highway improvement, Jefferson County's share	$239,274.41
Chapter 39, laws 1922, state aid to certain county highways	2,221,160.00
Chapter 41, laws 1922, highways, town county, repair bridges	2,395,000.00
Chapter 84, laws 1922, highways Monroe county's share	270,502.35
Chapter 240, laws 1922, maintenance and repair, state and county highways	6,150,000.00
	$11,275,936.76

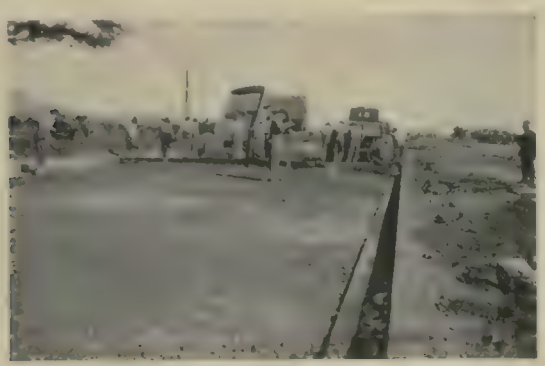
Bayfield County, Wisconsin, recently authorized the issuance of $110,000 road bonds.

The Missouri State Highway Commission recently approved contracts for 82 mi. of road at a total estimated cost of $496,395.

Equipment — Trade — Materials

CENTRAL MIXING PLANT ON ROAD CONTRACT AT COLORADO SPRINGS

One of the largest paving contracts ever let by a city at one time was awarded the Colorado Springs and Interurban Railway Company by the city of Colorado Springs, Colo., on June 24, 1921. This job involved the laying of about 253,000 sq. yd. of asphalt wearing surface on a 5-in. concrete base. The total value, together with incidental work ran something over $1,100,000. A unique feature of the contract was that any and all profits resulting should revert to the city for the benefit of the taxpayers. In the effort to reduce the expense as much as possible, the most approved layouts of material handling and concrete mixing were adopted by Superintendent R. H. Kimball, of the Paving Department of the Railway Co.



LAYING BASE, THREE MILE HAUL

At the time the contract was awarded the paving department was formed, the company being at that time without anything in the way of machinery or personnel. By Nov. 1, the job was 40% completed; by Jan. 1, 50% completed, at which time all operations were suspended on account of winter. It is expected that the job will be fully completed by July, 1922.

For this job the central mixing plant method was chosen and the mixed concrete hauled by auto trucks with steel dump bodies of 2 cu. yd. capacity. The maximum haul was 3.4 mi. and the minimum 1 mi. The average being about 2 mi. The largest number of trucks in use at any one time on the longest haul was 14.

The mixing plant consisted of a Smith tilting type mixer of 27 cu. ft. capacity. Both fine and coarse aggregate was maintained in bins under a railroad trestle, from which it was elevated by belt conveyors to the bunker over the batch boxes. The rock bins were about 350 cu-yd capacity and the sand bins about 300 cu. yd. Water supply came by 2-in. pipe from the main, and was measured by a Smith automatic tank. The average mixing time per batch was about a minute and a half. The day record up to Oct. 18 was 419 cu. yd., or 3,016 sq. yd. of 5-in. base. During the period from Sept. 30 to Oct. 13, an average of 2,311 sq. yd. of 5-in. base was maintained per 8-hour day.

For this amount of mixed concrete there was required at the central plant one man for each 2 conveyor belts, one man charging the batch hopper, one man pouring the cement in the batch hopper. One oiler, one foreman and 4 extras handling cement from the freight car or warehouse. When using cement from the warehouse the bags were conveyed up to the batch hopper by a belt conveyor. Insofar as was possible, concrete was unloaded directly in the batch hopper from the car, but in order to get the car out of the way and sometimes because the plant was not in operation, it was necessary to unload some of the sacks down a chute in the warehouse.

STREET PAVING IN PROVIDENCE DURING 1921

New paving constructed by the Department of Public Works of the City of Providence, R. I., during 1921 included 22,584 sq. yd. of sheet asphalt which was laid on both cement concrete and asphalt macadam foundations, and 217,436 sq. yd. of asphalt penetration macadam pavement.

In the sheet asphalt construction a 6-in. cement concrete foundation was employed on the section between the car tracks and in all inaccessible areas which it was believed would not be subjected to very heavy traffic. A 6-in. asphalt macadam base was utilized under that part of the sheet asphalt which was laid between the car tracks and the curb, and on straight stretches where it was anticipated the brunt of traffic would be concentrated. The asphalt macadam foundation consisted of 2-in. trap rock, thoroughly compacted. Texaco asphalt cement was applied by four auto-truck distributors owned by the city, and was spread at the rate of approximately 1.75 gal. per sq. yd.

The large yardage of asphalt penetration macadam was laid on the residential streets of the City of Providence, and is now subjected to a variety of traffic. The work has been so satisfactory that it is planned to lay a still greater yardage during 1922.

INDUSTRIAL RAILWAY ON ROAD CONTRACT

A contract has just been let by C. F. Lytle, road contractor, of Sioux City, Iowa, to the Koppel Industrial Car & Equipment Co., of Koppel, Pa., for furnishing narrow gauge track, cars, and batch boxes for a road contract Mr. Lytle has in Florida. This road is to be of concrete, starting at White House, Florida, and extending 43 mi. west.

The narrow gauge railroad will consist of 25 lb. track, on capped ties, each tie to have a ridge in the center, 24-in. gauge. The amount of track will exceed five miles. The necessary turnouts, switches, frogs, ground throws, curved track, etc., is included

in the contract. The contract also covers 75 batch box cars and 150 specially constructed steel bottom dump bath boxes, each box to carry 48 cu. ft. of aggregate. On account of the variations in the mix permitted under Mr. Lytle's contract with the State of Florida, the cement compartment in the batch boxes will be of the telescoping design.

MACHINE DEVISED TO TEST GRAVEL FOR ROAD BUILDING

To aid the Bureau of Public Roads in giving particular attention to the use of local material for road construction wherever possible, a simple, portable apparatus has been devised for testing gravel to determine its suitability for concrete. The device consists of two steel balls arranged so that a piece of gravel can be placed on top of one of the balls and the other ball allowed to fall from different heights and strike the gravel. The height of fall required to break the gravel is an indication of its suitability to withstand the blows of traffic.

Heretofore there has been no satisfactory test of gravel as there has been for stone, with the result that in some instances more costly material has been used when a suitable gravel was available close at hand. Along this line the bureau is conducting wear tests on concrete made of many different materials to determine just how far it is safe to go when the quality of materiial is doubtful.

MICHIGAN CONTRACTS FOR CEMENT

The approximately 1,000,000 barrels of cement to be used by the Michigan State Highway Department this year in its road building program will cost $2.05 to $2.26 a barrel, delivered where the work is being done. At this price, it is estimated by department officials, at least $100,000 will be saved to the state compared with previous years, with a possibility of additional savings in case of freight rate cuts on road building commodities.

The base rate to be paid by the state for its cement will approximate $1.40, at the mills. A lower base rate was obtained by other states represented at a conference in Chicago recently, when more than 2,000,000 barrels of cement was offered to the highway departments of Michigan, Ohio, Illinois, Indiana and adjoining states. The lower base rates, however, was carried in contracts which require the states taking advantage of it to take deliveries on high quantities of cement at specified times. This will require storage and rehandling, which, in the opinion of Michigan officials will more than offset the low base price. Michigan decided upon a 10-cent higher base rate with the privilege of taking the cement as needed and in contracts stipulating that any cuts in freight rates, or other conditions that might arise to lower cement prices, would revert to the advantage of the state.

MORE SURPLUS WAR MATERIAL AVAILABLE

Five million board feet of lumber and $220,000 worth of other surplus war material, consisting of steam and gas engines and machine-shop equipment, all unused, recently was made available to state highway departments for road construction. The material is to be distributed by the Bureau of Public Roads, as were large quantities which were helpful to many states in road building last season. Most of the lumber was intended by the Army for the construction of a pier at Charleston, S. C., and is suitable for highway bridges. The machinery and equipment are stored as ordnance supplies at the Picatinny Arsenal, Dover, N. J. This material is particularly in demand and an allotment has been requested by each of the 48 states.

DECADE SHOWS CHANGES IN TYPES OF ROAD MATERIALS

In the last 10 years there has been a great change in the type of road suitable for traffic conditions on main traveled highways, according to engineers of the Bureau of Public Roads. In 1910 plain and surface treated macadam were considered among the highest types of paving for country roads and a large percentage of the mileage was of the two types. There was a small mileage of brick and concrete and a somewhat greater mileage of bituminous macadam but the plain and surface-treated macadam were the predominant types of hard surface roads. How great the change has been is shown by figures recently issued by the bureau. On Federal aid roads completed between 1916 and 1920 only 2.9 per cent. of the total area paved was plain and surface-treated macadam. The types that formerly constituted such a small part of the mileage were as follows: Bituminous macadam, 3.1 per cent; bituminous concrete, 6.3 per cent; cement concrete, 19.3 per cent; and brick, 4.1 per cent.

MOTOR TRUCK REGULATIONS IN BRUSSELS

Belgian legislation requires trucks and trailers weighing 1 ton per axle and over to be equipped with rubber tires. Beginning March 1, according to the Independence Belge, of February 10, 1922, all trucks must have tires measuring at least 15 centimeters in breadth, and must be equipped with two independent sets of brakes capable of locking the wheels on the sharpest grades in the city. Regulations as to mufflers require silent motor operation, while exhaust must deliver the waste gases downward toward the ground. Existing rules requiring the presence of mud guards so constructed as to prevent all scattering will also be enforced more severely than heretofore.

Buncombe County, North Carolina, recently sold $100,000 of road and street bonds at a premium of $130 to the Provident Savings Bank and Trust Company of Cincinnati, O. The bonds bear 5% interest.

MEETINGS

Calendar of Coming Meetings

June 4-6—American Association of Engineers—Annual convention, Salt Lake City, Utah. Secretary, C. E. Drayer, Chicago, Ill.

June 13-16—Canadian Good Roads Association—Ninth annual convention, Victoria, B. C. Secretary-treasurer, George A. McNamee, Birks Bldg., Montreal, Canada.

June 26-July 1—American Society for Testing Materials—Twenty-fifth annual meeting, Atlantic City, N. J. Secretary, C. L. Warwick, Engineers' Club Bldg., Philadelphia, Pa.

Oct. 9-13—American Society for Municipal Improvements—Annual convention, Cleveland, O. Secretary, Charles Carroll Brown, Valparaiso, Ind.

GOOD ROADS CONGRESS IN ARGENTINE

The Touring Club Argentino has announced that, under its auspices, the First National Good Roads Congress will be held in Buenos Aires, Argentine, in May, 1922. At the termination of this congress a plan for the construction of a network of roads throughout the Republic, drawn up by the Touring Club Argentino, will be submitted to the Argentine Congress as a basis of proposed legislation.

It is estimated that a total of about 172,000 kilometers should be built over a period of 15 years, of which 153,940 would be dirt roads, 3,340 improved, 7,740 macadamized and 6,880 kilometers of such a construction as would prove most suitable to the particular region traversed. This would make about 18,000 kilometers of roads whose construction or repair would cost 19,400 Argentine paper pesos per kilometer; the cost of dirt roads is estimated at 6,500 Argentine paper pesos per kilometer. In order that this work may be carried out, it will be suggested that the Argentine Government authorize a loan of 550,000,000 pesos paper at par and for a period of 99 years.

If 18,000 kilometers of modern highways, not considering the dirt roads were added to the present main highway system of 13,000 kilometers, it is likely that the imports of motor vehicles would increase greatly, to say nothing of the large demand for road building machinery which would be created. An active participation in this congress will thus prove of great value to American manufacturers interested in introducing or developing the sale of their products in this market, especially as one of the features planned for the delegates and the public in general is a parade of vehicles of all kinds and the construction of a section of highway by means of modern road building machinery and equipment.

TEXAS ROAD BUILDERS' ASSOCIATION

The annual meeting of the Texas Road Builders' Association will be held at Austin on April 17. At the Texas Good Roads Show held at Fort Worth on March 15 and 16 a committee was appointed to revise the constitution. As the coming meeting the committee will recommend that membership dues be reduced from $10 to $2.

AUTOMOTIVE CONDITIONS IN CHINA

A monograph "China: Automotive Conditions and the Good Roads Movement," by J. Morgan Clements, American Trade Commissioner, March 2, 1922, may be obtained on application to the Automotive Division, Bureau of Foreign and Domestic Commerce, Washington, D. C.

Among other conclusions, the writer states that although China's increasing interest in road building is an encouraging sign, American manufacturers should by no means jump at the conclusion that an immediate market will be created for large numbers of motor cars and trucks.

Summit County, Ohio, plans to pave 40 mi. of road during 1922 at a total cost of $1,500,000, according to Jack Weaver, County Engineer.

PERSONAL MENTION

Walter Barber, at one time county engineer of Clay and Osceola Counties, Iowa, has been appointed assistant city manager of Long Beach, Cal.

F. C. Brush has been appointed city engineer of Norwich, N. Y.

Arthur P. Denton has resigned as district engineer of the Portland Cement Association to become sales manager for the Pacific Portland Cement Co., San Francisco, Cal.

H. B. Belford has been appointed resident engineer of the Illinois State Highway Department, with headquarters at Carbondale.

Samuel Hart has been appointed deputy city engineer of Sacramento, Cal.

B. C. Brennan has resigned as city engineer of Kenosha, Wis., to enter private practice.

John Sears has been appointed resident engineer for the Ontario Department of Public Highways, with headquarters at Chatham.

L. W. Wynne-Roberts has resigned as resident engineer of the Ontario Department of Public Highways.

George Stephenson has been appointed engineer of Bruce County, Ontario.

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TABLE OF CONTENTS

The Appearance of Our Highways. By Charles F. Boehler 205

The Construction of Concrete Pavements. By W. E. Hawkins 210

Much Lower Bids Made for the Construction of Hard Roads 212

Goods Roads Will Help the Farmer 213

Cheap Team Hire Encourages Winter Road Construction 213

Road Marking and Signing in Wisconsin. By N. M. Isabella 214

Indiana Commission Receives Many Bids 216

"Dumorite" Meets Requirements in Field 216

Effect of Moisture on Concrete 217

Data on Road Construction to be Put in Usable Form 217

Eighteen States Tax Gasoline 217

EDITORIALS:

Highways and National Unity 209

Gasoline Taxes for Road Funds 209

Forms in Concrete Construction 209

MEETINGS:

Calendar 218

National Highway Traffic Association 218

PERSONAL MENTION 218

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THE HIGHWAY CONTRACTOR AND ROAD BUILDER

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The Appearance of Our Highways*

By CHARLES F. BOEHLER†

The highway officials and engineers of today have a great opportunity before them. Highway construction, slow to develop at first, has gained a tremendous impetus and vast sums have been intrusted to the highway officials and engineers to expend for what the public hopes to be permanent improvements.

Highways yield three returns to the public: service, safety and appearance, and they should be so designed as to combine service and safety with the greatest degree of beauty possible. The highway engineer has been confronted with a succession of problems to meet the rapidly changing traffic conditions. As the traffic conditions have almost completely changed in the last few years, the experience of the past has been of questionable use in the design of highways for the future. The few books written on the subject have soon become out of date and the highway engineer has been forced to rely to a great extent on his own judgment and experience and to adopt the best ideas of his contemporaries. Under these conditions of rapid changes it is not strange that the engineer has concentrated so much on improving the road surface that he has had little time to devote to the appearance of the highway and to the design of the right of way as a complete unit.

While there has been definite progress made in the design of the road surface and in some cases an effort made to beautify the roadsides, in general, little attention has been paid by highway engineers and officials to the appearance of the highway; this matter being left to the abutting property owner to do as he saw fit.

The system of depending upon the abutting property owner entirely to add beauty to the highway has not proven generally successful for the reasons that there is great variation in the desires of individuals for such improvement and in the ideas of individuals as to how to beautify the roadsides. While attractive highways add to the value and appearance of the abutting property and the property owner therefore has an interest in the appearance of the roadsides, their greatest effect is on the traveling public and the public has a proportionate interest in their appearance. There should be no tendency to prevent the beautifying of the roadsides by the property owners, in fact, this should be encouraged; but it should be done in a way to harmonize with a comprehensive plan for the whole highway and in line with its future requirements. It becomes a duty of the highway official and engineer who represents the public, to plan for the attractive appearance of the highways in a comprehensive way and to encourage the proper development of the roadsides by property owners, but at the same time to so guide and direct the work that it will be a public improvement as well as a benefit to the individual.

Highways are not unlike other public improvements in that beauty of design should be one of the requirements and this should be considered and provided for by the authorities having charge of such improvements. Today we are at the point where we realize that the appearance of the highways is a public concern, where we realize that we should not expect the individual to handle the problem of adding beauty to them in any comprehensive way without guidance, so, today the highway officials and engineers have a great opportunity to design the highways to be beautiful as well as useful. If they rise to this opportunity, the public will appreciate it and the property owners along the way will benefit, but if they do not, their work will be incomplete, the public will be deprived of attractive scenery it should be entitled to and the property owners will suffer.

Centuries ago, architects built beauty into the great cathedrals of Italy, France and other European countries and today St. Peters, St. Marks, St. Pauls, Notre Dame, and the cathedrals of Louvain, Cologne and

*Paper presented at eighth annual conference on highway engineering of the University of Michigan.

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many other cities stand as monuments to the ability of the architects who considered beauty in their design. Rising from the ruins of a destroyed Paris there appeared a city better planned than before, a city that probably has no equal in its magnificent boulevards and parks, its buildings and monuments, all because the destruction of the old city gave the opportunity and there were men broad enough to s.ize this opportunity to plan a better city. Not always is a catastrophe necessary to give the opportunity for proper planning. Our own City of Washington stands as a splendid example of city planning because Washington had the foresight to secure the services of a man with a vision to plan a great capital city. We are considered a commercial people, but our great engineers and architects are producing works of beauty as well as utility. The Panama Canal, the Croton Dam and other great engineering structures were designed to be pleasing in appearance. Modern railroad stations, hotels, banks and office buildings are being made attractive without any sacrifices of their utility. The beauty of the world's great buildings, engineering structures and cities becomes part of them and they increase in public appreciation because of this.

Fortunately, as in buildings and cities, it is possible to make highways attractive without any sacrifice of utility by the use of proper design. If we would make our highways of permanent benefit to the public, we should design them to meet the three requirements of service, safety and attractive appearance. It is not enough to simply meet the requirements of utility, nor is it enough to simply make them beautiful; but until we design the entire highway as a complete unit which will serve the purposes of traffic and present that pleasing appearance required generally of public works, we have failed, at least in part, in our work as highway engineers and officials.

When we study the world's great buildings and see the influence that their beauty has had in their appreciation by the public, when we realize that there is an inherent love for beauty in mankind that is always seeking means of expression, when we realize that highway improvement is a tremendous public undertaking with an opportunity to provide for beauty that would be appreciated by a large proportion of our population, then we would expect a tendency among the people to demand more beauty in our highways. We find that there is a strong sentiment in this country for making our highways more attractive. This sentiment is widespread, not limited to a few localities but it has appeared in many parts of the state. and not only in Michigan but quite generally over the country.

While the movement toward roadside development is a logical outgrowth of such a great undertaking and would have come naturally in time, undoubtedly one of the big factors to bring it to a focus was the effect of the orderly and attractive highways in France on our soldiers who served there. We find the American Legion has adopted the planting of memorial trees as a national policy with the possibility of 11,000 posts working in unison to beautify our highways; we find the Daughters of the American Revolution, the Grand Army of the Republic, local chambers of commerce, women's clubs and other organizations behind this movement and the press of the whole country favorable to it.

While such factors as pleasing grades, suitable width of road surface, well turfed shoulders, slopes and ditches have considerable to do with the apparance of the highway ,the greatest factor for the beautifying of the highways is the development of that part of the right of way outside of the ditches.

The present tendency to reduce the depth of ditches and to depend more on tile under-drain for our drainage not only increases the safety of traffic but improves the appearance of the roads as well. The sodding of slopes, ditches and shoulders where the soil is too poor for successful seeding is advisable from the standpoint of lessened maintenance, as well as improved appearance.

In the development of our roadsides, the question of design is of prime importance. If we had only the road surface and the planting of roadside trees to consider, the question of design would be simple; but our highways are used for other than purposes of travel. By legislative enactment, telephone, telegraph and power companies use the highway right of way for the erection of their poles and lines. To most people such poles and wires are unsightly and in many cities the wires are required to be placed in underground conduits or in cables, but we must consider them as necessary in the design of our highways. In the design of the whole right of way sufficient width should be allowed for the requirements of traffic and the proper drainage of the road by side ditches. A space should be reserved for tree planting and a space for the erection of poles and the stringing of wires. In our normal 66-ft. right of way we ordinarily have room for all these requirements. If we allow 18 ft. for road metal, 4 ft. for the width of shoulders and 6 ft. for the width of ditch, it would allow 14 ft. of width for trees and poles. The proper position of the poles should be either as close to the outside edges of the normal ditch as reasonable or at the extreme outer edges of the 66-ft. right of way. Whether the trees or poles should have the outside position would depend upon local conditions. From the standpoint of appearance, I favor the outside position for the trees but the reverse position has some advantages. The point which I would like to emphasize is that neither trees nor poles should be placed midway between the edge of the ditch and the edge of the right of way. If poles are so placed it does not leave sufficient room for trees on either side and if trees are so planted it does not leave sufficient room for poles on either side. While existing trees

have considerable to do with the location of poles, it is important that we follow a standard practice wherever it is possible so that in a few years we will have orderly highways with trees growing in the place reserved for them and the poles where they should be. We have every evidence of the cooperation of pole using companies in this matter and we should further this cooperation especially, in any planting that is done, by being sure that the trees are planted in the part of the right of way that will accommodate properly placed poles in the future. As the highway authorities are in the best position to know the future plans for the highways, it should be required, in all cases where the erection of poles or general replacement is contemplated, that the pole using company take up the matter with the authorities having jurisdiction over the roads to determine the proper position of the poles. In cases where road construction requires the removal of poles, the highway authorities should indicate what part of the right of way the poles should be placed at the time of ordering their removal. In some cases, especially where large trees in the highway make a private right of way desirable for a line of poles and in many cases where the poles should be placed at the extreme outer edge of the right of way with the cross arms overhanging private property, the permission of the abutting property owner is required and the support of the highway authorities makes it easier to secure such permission. In such cases the highway authorities should be ready to give this support to further the necessary cooperation between pole using company, highway officials and abutting property owner for the benefit of all.

In order that the roadsides may be made attractive and their beauty preserved it is necessary that there be suitable legislation to cover this. The laws of Michigan are favorable to this work, forbidding the cutting or injury of roadside trees without the permission of the highway authorities, providing for the planting and care of trees along the state trunk lines and federal aid roads under trunk lines and federal aid road maintenance and providing that counties, townships, cities and villages may appropriate funds for this purpose. In the case of state trunk lines and federal aid roads it is provided that the trees must be obtained from the State Agricultural College, from some other state institution or from neighboring lands without cost. This provision is working out as an advantage as it stimulates the cooperation of local organizations in supplying trees for this work and insures a healthy local interest. Legislation of a somewhat similar nature has been enacted in other states, including California, Illinois, Maryland, Massachusetts, New Jersey, NewYork, Oregon, Pennsylvania, aod Washington, as well as others. Although in some cases, the legislation is so imperfect that no actual work can be done, it shows an effort to provide for this work and undoubtedly before many years.

The general policy for planting in Michigan includes first a formal application from the county for such planting and on this basis as rapidly as possible, definite planting plans are prepared. In some cases, suitable trees can be secured from the State Agricultural College or they may be obtained through donation from nearby lands, while in other cases local organizations have offered to supply the trees required for certain roads. In numerous other instances, local organizations have made arrangements to plant memorial trees, or abutting property owners wish to plant along their frontage and the state has been consulted relative to the proper arrangement of the trees. In all cases the intention is to study the conditions and make the planting plans fit these conditions and conform to the best future development of the highway. In some places, regular rows of trees are provided for while in other locations, especially in the more rugged regions, a naturalistic arrangement of trees in irregular groups is more fitting. The varieties are chosen with regard to the types of soil and other conditions that might limit the growth. Where planting is desirable but the available space is taken up by lines of wire, the smaller growing varieties are chosen to prevent future interference of the wires, but where there is room for the trees to grow up past the wires the taller varieties are chosen, providing for undertrimming and the use of shorter poles. It is considered far better to study the grounds carefully and adapt the type of planting to the existing conditions than to conduct the planting on a larger scale, on the basis of set rules requiring regular spacing of the trees under all conditions. The promiscuous planting of trees in straight rows and at regular intervals on all our roads would result in monotony while moderate planting in this way varied with the informal type of planting where that type is adapted would result in more picturesque and interesting highways.

In the choice of varieties and the general arrangement of the planting it is the intention to consider the abutting property owner and to so plan the work that it will be a benefit to him as well as an improvement to the highway. As there are many kinds of useful and ornamental trees adapted to different conditions of soil and growth it is usually possible to secure the full cooperation of the abutting property owner by choosing the kind of trees we are providing for the future appearance of the highways. While there is noticeable improvement in appearance in a few years, we are really planting for twenty-five, fifty or a hundred or more years in the future. While this is work that will be appreciated by future generations, we should not lose sight of the fact we have existing, along many of our roads, trees that are already fifty or a hundred years old and young trees that only need the proper care and protection to make the roadside attractive.

A few years ago there was a tendency to cut all

shrubs and young trees from the roadsides and this tendency is still noticeable in some localities. Those same roadsides, made barren through this wholesale clearing are now being considered for planting. How much more reasonable it is to cut only the undesirable growth and to reserve the desirable trees, shrubs, and vines, thereby saving expense, labor and years of waiting, besides producing roadsides more attractive than those planted by man.

In the cleaning up of the roadsides, let us save the young trees, even if we have too many they are producing useful wood and the surplus can be cut at any time. Let us save such attractive flowering trees as the thornapple, the dogwood, red bud and shadbush and such shrubs and vines as the red osier, witch hazel, wild rose, sweet fern, meadow sweet, clematis, bitter sweet, wild grape, woodbine and even the elder and sumac. If we realize that all these plants are grown in great quantities in nurseries and used for ornamental planting in parks and private grounds, we will see that they have value and surely it is unreasonable to destroy such plants and at the same time provide for other planting.

In the preservation of our roadside trees, the trimming and cutting by different pole using companies as well as private individuals has been a problem. Under our tree protection law, enacted last year, companies wishing to do trimming or cutting along the state trunk lines or federal aid roads, make formal applications for tree trimming or tree cutting permits to the State Highway Commissioner. Then arrangements are made to go over the proposed work by a representative of the state, county and company, specific instructions given and a permit granted on the merits of the case. The company is also provided with a set of general instructions and the permit is subject to revocation if the work is improperly done. The intention is to depend as much as possible upon the county organizations to see that such work is properly done, on the same basis as truck line maintenance is handled, with a general oversight by the state. While this law has been in operation only a short time it is gratifying to note the spirit of cooperation which is manifest among the pole using companies. Many trees have already been saved and the quality of tree trimming is improving. Especially is this true where the more progressive companies have placed their tree trimming in charge of trained foresters. We still have some unauthorized cutting by individuals, but such cutting is usually done by men ignorant of this law and they stop this destruction when the law is explained to them.

Some of the questions that a few years ago were evident in the problem of roadside development have been answered here in Michigan. It is generally recognized that it is desirable to make our highways more attractive, there is a general demand that roadside planting be done and there is a spirit of cooperation between the highway authorities, local organizations, residents along the way and pole using companies. We now have favorable legislation, the lack of which for a long time prevented effective work, and we have adopted a policy for handling the work. The great need now is for men trained along these lines to carry out this work successfully. I am convinced that highway engineers should study the subject of roadside development and proper tree trimming. In some cases counties have added to their organizations men who are trained in forestry and landscape engineering and the results of their work already justify this move. Other counties are planning to place the work of tree trimming and tree planting in charge of experts. It is quite evident that this move is right, for we cannot expect good work from unskilled or improperly directed workmen in any line of endeavor and especially in a work such as this, where faults are not evident for perhaps several years. Some of the pole using companies are placing their tree trimming in charge of trained foresters and there is no comparison between the work done in this way and that done by linemen and others who have not made a study of tree trimming for the benefit of the tree. There has been a great deal of public criticism of pole using companies for trimming that has been done in the past, but there is no reason why this criticism could not be changed to approval if the necessary tree trimming is done in a scientific manner by experts. The work costs no more when properly done but the results are lasting and the confidence of the public is gained. I am sure that the progressive companies wish to do this work right and gain the confidence of the people, but we as highway officials and engineers should be in a position to know what proper trimming is and to insist that proper trimming be done.

We have the public demand for better appearance in our highways, we have the cooperation of the people in this work, we have the legislation, the means and a general policy and we are beginning to get men trained in the work, but our greatest need is the men. With a better knowledge of this work among highway engineers and officials, with enough trained men to carry it on, our roadsides will be made attractive to the lasting pleasure and benefit of the people.

Finance Commissioner, Richard Murphy, of New Orleans, La., has requested the Board of Health and the Police and Fire Departments to voluntarily cut their budgets in order that the city may take advantage of the satisfactory prices obtained at this time to carry out the entire 1922 street paving program.

Allen County, Ohio, after several years delay, plans to join the good roads movement by spending $1,250,000 on highway improvement this year. The bonds have been sold and work will start immediately.

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

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Editor

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Articles by road builders are solicited. They should be short and, if possible, accompanied by photographs. Those accepted will be paid for at current rates.

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GASOLINE TAXES FOR ROAD FUNDS

Four states have recently enacted a tax of one cent per gallon on gasoline, making a total of 18 states which utilize this source of revenue. Measures proposing the taxation of gasoline are now pending in two other states. Next year the legislatures of 34 states will convene and it is probable a number will enact gasoline taxes to augment their road funds. Very likely within a few years practically every state will be securing an important part of its road revenue from gasoline taxes.

A gasoline tax is one of the most equitable taxes that can be levied on automobiles, in that motor vehicle owners are assessed in proportion to the use they make of the highways. However, a gasoline tax has its limitations and can not be used in lieu of other taxes on motor vehicles. For example, a motor truck with a load of five tons will cause more wear and tear on a road in consuming ten gallons of gasoline than will a light passenger car using the same amount of gasoline.

The road funds of more than half of the states in the Union can be materially increased by the adoption of gasoline taxes. Current road revenues ought to be made as great as possible so as to avoid excessive bond issues. With one exception, the State of Oregon, which has a gasoline tax of two cents per gallon, gasoline taxes so far imposed are uniformly one cent a gallon. A bill is pending in the Maryland Legislature, however, which proposes a two cent tax. Just why a one-cent tax has been adopted generally is not apparent. In some states with large mileages of improved highways a much larger tax would be entirely justified, for the ton-mile cost of operation of a motor vehicle on a paved road is much less than on a gravel or earth road.

FORMS IN CONCRETE CONSTRUCTION

Great care must be exercised in the construction of modern highways; a neglect of details may diminish the value or life of a pavement. For example, it has been found that the weight of the forms used in the construction of a concrete road has a direct bearing upon the finished surface.

"Steel forms weighing about four pounds to the foot were at first used," writes W. E. Hawkins, Assistant Engineer of the North Carolina State Highway Department, in an article appearing elsewhere in this issue, "but constant use, coupled with careless handling, caused poor alignment, grade and finish. This weight has been increased from time to time until experience has demonstrated that with each increase of form weight, better results have been obtained in surface finish and riding qualities."

HIGHWAYS AND NATIONAL UNITY

When the Federal aid highway system provided for by the recently enacted federal highway act, is completed there will be a network of roads 180,000 mi. in length covering the whole United States. The time required for the completion of the system will depend upon the rate at which the necessary Federal funds are provided.

An idea of what these roads will mean to the country can be gained by studying the effect of roads built in recent years and picturing what would happen should they be torn up and left in their former condition.

Should these roads go back to their former state and the motor vehicles which have come with them disappear there would be many changes. Many suburbanites would have to move into the city and there would be a decrease in value of suburban real estate. Cities would have trouble in getting their fresh milk and food supply. Much farm land would decrease in value and the effect on rural social life would be serious. In fact, motor vehicles and the roads on which to use them form such an important part of our economic and social life that it is hard to picture to the full extent what would happen.

Since all this dependence on highway transportation has come in a brief period of years and with the construction of 115,000 mi. of surfaced highways, 60,000 of which are on the proposed Federal aid highway system, it can be understood what further changes will take place as the system grows to 180,000 mi. in length and other roads are built branching out from it.

The Construction of Concrete Pavements

By W. E. HAWKINS†

In the consideration of permanent roads it is seen that we have been passing through an age of transition regarding methods of construction for the past fifteen years. The public has now begun to realize what a good road means, with the result that large sums of money are being appropriated for the construction of better and permanent roads. North Carolina, being one of the foremost states in the Union, has followed the lead of other states and ten months ago launched out upon an ambitious good roads construction program.

Engineers have been striving for years to develop and construct a permanent road, a road that would be giving the public their money's worth, that, with proper maintenance would still be in existence upon the maturity of the bonds, and one that would satisfy the requirements of the public.

Approximately ten years ago, concrete received its first impetus in roadway construction. With the increase of motor driven vehicles it was found that further construction of macadam roads with their excessive maintenance costs was a waste of money. With this realization several states built sections of concrete roads where traffic was heavy. The question of strength and wearing surface at first was not given proper consideration, with the result, that failures occurred in a very short time. With the increase in traffic the riding surface of the pavement gave way to rough and uneven places, and as the strength of the pavement was not sufficient to withstand the ever-increasing load, numerous cracks occurred at different points in the pavement.

In the past failures of concrete pavements have been attributed to, improperly prepared subgrades; inadequate drainage systems; the use of aggregates which were not clean, well graded or properly proportioned; the use of cement that had not been properly tested or stored on the job; inadequate or irregular mixing; the use of too much water, and a scarcity of cement. In many cases the pavements were not built to specified depth, and the reinforcing material was not placed as specified. Failures also resulted when poor finishing methods were employed or when the curing was not carried out according to specifications. The subgrade must be uniform; well drained at all times; soft or wet spots must be removed; free from an objectionable material; have no ruts, bumps or low places; and be firm and well rolled. It is a waste of money to lay a concrete road upon a subgrade that is not properly prepared, for in due time failure of that section of pavement will surely result.

After the subgrade has been properly prepared, forms should be erected according to alignment and grade as given by the engineer. The riding qualities of a concrete road depend to a large extent upon the forms. Wood forms have shown by experience to be unsatisfactory, as they soon become warped, split and broken. Steel forms weighing about four pounds to the foot were at first used, but constant use, coupled with careless handling, caused poor alignment, grade and finish. This weight has been increased from time to time until experience has demonstrated that with each increase of form weight, better results have been obtained in surface finish and riding qualities. Forms must be oiled or greased each time before use. At all times they must be set accurately, with good alignment, grade and stability. Poor line, grade and insufficient staking will result in uneven and rough riding surfaces. Two hundred feet of forms on both sides must be set at all times in advance of the mixer in order to insure proper alignment and grade.

The materials entering into the construction of the road should be first class in quality, as they are the vital parts of the pavement. All materials must pass a rigid laboratory test before being used. This is especially true of the fine aggregate, as poor quality in this material in the past, has been responsible for many failures in concrete pavements.

Cement should be sampled from cars when loading at the mill. The cement must be carefully stored and kept dry. Under no condition should it be placed on the ground. When cement that has not been tested arrives at the work, it should not be unloaded until sampled. Until a report has been received the cement should be carefully stored in a shed, and so placed, that it can easily be identified in case of necessity. All materials used must be well graded, clean, tested and approved by engineer of tests before being used in the work.

In regard to the strength and section of concrete pavements, we have two types, a road with a flat subgrade, 6 to 8 in. thick at sides and 8 to 10 in. thick in the center. This design has been found to possess sufficient strength and endurance to take care of our future traffic needs. The other type is a pavement of uniform thickness with fabric reinforcement placed 2 in. from the surface which in some cases will prevent racking, while in others will prevent cracks from opening up. This reinforement also gives pavement sufficient beam strength to counteract any transverse and longitudinal cracks which would have eventually developed had the pavement not been reinforced. With our present design of fabric reinforcement with marginal bars at the sides of the pavement, a road of 6 in. uniform thickness, so reinforced, will certainly prove durable and suitable to the traffic needs of this state.

†Assistant State Highway Engineer of North Carolina.

There are three methods now being almost universally used in the mixing and placing of concrete roads. First, the central proportioning plant, where the aggregates are proportioned at a central plant, placed in measuring or batch boxes, and hauled by trucks or industrial railway to point of use. Second, central mixing plant, the concrete being prepared at central plant and hauled to point of use by motor truck for distances of several miles. Third, materials being distributed along project adjacent to road in storage piles at distances of from 500 to 1,000 ft. and hauled in carts or trucks, with proportioned compartments, to point of use.

Under no consideration should materials be allowed to be dumped upon the subgrade. Experience in the past, with this method, has demonstrated that the subgrade has not been properly prepared before materials are placed thereon. Wheel-barrows, as measuring devices have not given satisfaction. Aggregates shoveled or forked with this method become mixed with dirt and other objectionable material.

The correct measuring of all materials insures satisfactory work. The contents of all proportioning boxes, batch boxes or other measuring devices must be determined by accurate measurements. Poorly proportioned and weak batches in a day's run result after a few years' service in pot holes, and surface disintegration, which affect riding qualities of road and require maintenance. The inspector should keep an accurate check on the amount of cement used, maintain a daily record of length of pavement laid, and report daily, to the district engineer the quantities of cement used.

The next important step is the mixing of the materials. They should be mixed for 1½ min. in a batch mixer equipped with a timing device attachment. Water should be added at the time the materials are being run into the mixer. In the mixing of concrete the time of mix and the water factor are most important. As a general rule the less water used and the greater the time of mixing, results in a stronger concrete. A concrete of proper consistency can be obtained with less water if the time mixing is increased. Many thousands of dollars are wasted by the use of too much water during mixing. It is obvious that a larger amount of water will allow a mixer to turn out what looks like a well mixed concrete but in such cases we do not get proper hydration of the cement. The concrete should come from the mixer with every particle of the fine and coarse aggregate coated with cement, when deposited it will be neither sloppy nor granular but a uniform mass.

Before placing concrete, the subgrade should be tested with a subgrade tester to insure proper depth of pavement. The subgrade must be firm, smooth and uniform. Concrete shall be placed only on a moist subgrade and by means of a discharging device which does not cause separation of matrix and the coarse aggregate. If concrete is too wet, the mortar will separate, leaving the coarse aggregate pocketed. This results in concrete which is weak in spots. The use of short handle, square-pointed shovels allows the laborers to deposit the concrete in a uniform mass more than the use of any other implement.

If fabric reinforcement is used, it must be perfectly flat when placed in the work. If finished in rolls, it must be flattened by the use of a machine. The fabric must extend to within 2 in. of the sides of the pavement, and must be lapped one-half the distance of the spacing of the main members. If the reinforcement is placed lower than 2 in. in the pavement, the desired result is lost. A striking template insuring a 2-in. depth must be used in order to secure uniformity. The first layer of concrete shall be deposited to the depth of fabric reinforcing and then struck off with approved template. After reinforcement is in position, the remaining 2 in. of concrete is placed on top of it. Workmen should not be permitted to walk in the concrete after the initial spreading.

As soon as the full depth of concrete has been spread, it shall be struck off, either by a hand template or an approved finishing machine. The hand template should weigh not less than 400 lb., and shaped to cross section of road according to plans. A slight excess of concrete must be maintained ahead of the strikeboard at all times. The template must be worked in a crosswise and longitudinal movement, always keeping an excess of concrete ahead; this will insure a uniform and true surface. Before the pavement is struck off, the sides must be spaded in order to prevent honeycombed sections and to insure satisfactory edging. Templates, both hand and finishing machine, must be checked morning and noon for crown. Sufficient allowance must be made for the slump of concrete in hardening. They should have a crown of at least ¼ in. greater than crown of finished pavement.

After the concrete has been struck off, it should be rolled with a roller of size and weight according to specifications. This removes all air-bubbles and pockets in the concrete. The use of the roller must not be delayed until the surface is partially set. Too early rolling will remove too much mortar and not water. The roller must be moved slowly, passing over surface and back, it is then lifted and advanced one-half its length, the rolling operation then being repeated. Free water must be allowed to come to the surface between each rolling, and the rolling continued until this ceases. The roller must be wetted after each operation and kept clean and true in form.

After final rolling, the belting of the surface should follow. The belt must be kept moist or oiled and cleaned at all times. It should be made of a composition and size according to specifications. The first belting of the surface takes out small irregularities, romoves excess water and smooths the surface. It is necessary to repeat this operation to secure the desired results. The final belting must be given the surface

when concrete has partially set, all excess water having been taken off and the finished surface resulting should be uniform and of gritty texture. The belt should not be allowed to rest on the fresh concrete at any time.

In the use of the finishing machine, poor results have been obtained in the past, because of inexperienced operators. An operator must be experienced, or instructed and trained to finish a pavement which is uniform. The defect of finishing machine work is an irregular wavy surface, which is caused in a number of ways. These can be remedied by not allowing machine to move too fast, keeping excess of material in front of strike-board and a proper amount of tamping. The tendency in the past, has been to finish the surface entirely too wet.

To overcome this, the surface should be required in all cases to be rolled with a hand roller as hereinbefore described under hand finishing.

The placing of transverse joints in a concrete pavement has had a number of years of experiment. Some engineers are still placing joints at from 25 to 40 ft. apart unreinforced, with a joint filler. It has been demonstrated that the best results will be obtained by placing joints reinforced with dowel rods at the end of each day's work, with joint filler of from ½ to 1 in. This will allow free movement as the slab expands or contracts.

The last operation in the construction of a concrete pavement is that of curing. The best method of curing is obtained by ponding. Tests have shown that additional strength and better wearing qualities have been obtained by proper curing of concrete. As soon as the surface of the concrete is finished, it should be protected by canvas or other similar material, placed on frames or on the surface of the pavement. Another practical method is that of placing burlap on the surface of the concrete as soon as it has sufficiently set to bear same, without marring the surface finish. This is kept wet continually during the day's run, and removed next morning; when the surface should be covered with 2 in. of earth and kept wet continually for next two weeks. Hair checking or cracking can sometimes be eliminated by the use of the wet burlap, placed on the surface. If this does not prevent it, then coarse and fine aggregate should be sprinkled before being placed in the mixer. The pavement, after receiving earth covering should be kept wet or soaked for 14 days, and under no consideration should traffic be permitted on the pavement within less than 21 days.

Before traffic is allowed on the pavement, all joints and cracks should be sealed with tar or asphalt. Applications should be poured flush with openings, in narrow widths and straight lines. Material should only extend 1 in. on each side of joint or crack; after application, the material should be covered with coarse sand.

Shoulders should be built adjacent to the pavement in accordance with plans in a reasonable time. They should be built of such material, and on a slope that will allow water to flow quickly away from the pavement, and be sufficienty firm to protect the edges. In order to insure a long life road, side ditches having a minimum depth of 9 in. below the bottom of pavement should be constructed throughout the entire length of pavement and small outlet trenches or drains in the shoulders should be built on grades, and at all low points in vertical curves at break of grade to prevent moisture from seeping under the pavement. If the foundation is not properly drained, cracks will eventually occur in the surface, which will cause failure of the pavement in time.

Careful and competent inspection should be applied at all times during period of construction. The idea of inspection is not to cause annoyance or arguments with the contractor, but to help him get the best results possible by watching careless employees and guard against faulty methods and the use of materials that would be detrimental to the work. Careful surveys may be made, and specifications and plans carefully prepared, after the most thorough investigation and study of conditions. The best material may be used, and without the proper combination of materials, and careful workmanship at all times, along with continual, careful inspection, the work may prove to be a failure in due time.

Every operation in the construction of a concrete pavement is an important one, therefore, attention should be given to all the details of construction. These many details are never too small, for the moment that we become lax a failure in the pavement will surely result. It is our aim to get the best and smoothest riding pavement possible and this we have not as yet attained. The design and construction of concrete roads is still passing through an age of transition. It still demands a great deal of study, and in order to get the maximum results from our efforts, with a minimum of expenditure, we must follow first class methods in construction.

MUCH LOWER BIDS MADE FOR CONSTRUCTION OF HARD ROADS

Early bids for the construction of federal aid roads indicate that prices during the coming season will be materially lower than last season, according to reports received by the Bureau of Public Roads. While bids have not been received on any large volume of work, there is, however, enough to indicate a lower level of prices.

Grading has been bid at 20, 23 and 30 ct. a cubic yard in Missouri, Arkansas and Minnesota, respectively, as compared with an average of 35 ct. for the section in which these states are located in 1921.

Prices of reinforcing steel in place range around 6 ct. as compared with the 1921 price of 8 or 9 ct. and bridge steel at 4¾ ct. against 7 to 8 ct.

A few bids, for the best grade of concrete, of about $17 a cubic yard have been received in sections where the 1921 price was about $25 a cubic yard.

Prices bid for the construction of concrete roads per square yard are as follows: Ohio $1.52, Colorado $2.27, and Georgia $1.38, as compared with an average for the whole country during the period 1916-1920 of $2.57 a square yard.

GOOD ROADS WILL HELP THE FARMER

Highway Transportation Committee of Recent National Agricultural Conference Urges Continuation of Federal Aid Appropriations to Build Market Roads.

The Highway Transportation Committee of the National Agricultural Conference, held in Washington, D. C., on Jan. 23 to 27, filed the following report:

Country highways are the farmers' first and principal transportation means of marketing their products. They are the arteries of the economic and social system of the country. On their condition rests the amount of transportation charge that must be added to the gross cost of farm product and the more fully they are developed, the less that weather conditions and soil are allowed to clog the flow of traffic, the greater will be the health of the body politic and the added profusion of enjoyments and privileges to the common people.

The loss from bad roads should be reduced to a minimum, not only to enlarge the farmer's market but to shorten the time and reduce the spread of price between the farmer and the consumer.

Th farmer ought to be able to haul to market twice as much twice as often as he has been able to do it in the past. If the farmer is to be put in a position to help influence the price of his products by not dumping them on the market for fear of unseasonable weather, he must control the condition of the roads to his markets. Without proper road conditions "orderly marketing" can never be accomplished. Rapid growth of traffic over the highways has been so greatly intensified during the past few years that this method of transportation needs earnest and careful consideration. To this end we urge the closest coordination between the three major forms of transportation so that railways, waterways and highways may each carry the kind of traffic that it can the most economically, expeditiously and efficiently serve.

We commend the Department of Agriculture, state highway departments, and colleges for their research in connection with highway construction, maintenance, and transport over the highways, and urge full support be given these investigations.

We approve the action of Congress in continuing federal aid for the building of interstate, postal, and farm-to-market highways under the Department of Agriculture and making appropriation therefor. We believe this policy to be equitable and constructive. We urge Congress to continue this policy for a definite period, so that the states may plan adequate cooperation.

We call particular attention of federal and state authorities to the growing necessity for regulation of traffic on highways in order that they may be protected from excessive and destructive abuse. Research into causes of highway wear should be continued by the Department of Agriculture and state highway departments and traffic regulated according to the facts developed.

It is self-evident that farm products are the most cheaply transported over well-kept highways. We, therefore, urge that all possible safeguards should be placed about the maintenance of highways.

Safety of life and limb on the highways is paramount, and we favor every effort to make the use of streets and highways less dangerous to all citizens.

We commend the Department of Agriculture for its policy in highway improvement, of providing roads suitable for horse-drawn as well as motorized vehicles, and urge that wherever practicable side roads be constructed adjacent to the metal surface portion of the highway.

Rapidly changing traffic conditions on our thoroughfares make the construction and maintenance of our highways an important engineering and business undertaking; therefore, all partisan or political consideration must be eliminated.

CHEAP TEAM HIRE ENCOURAGES WINTER ROAD CONSTRUCTION

Prices for the hire of teams in winter offer considerable inducement for carrying on certain classes of road work where conditions are favorable during the winter months, according to figures collected by the Bureau of Public Roads on federal aid projects.

In January and February teams without drivers could be secured at 28 ct. an hour in the states between the Ohio and Mississippi Rivers; from 31 to 52 ct. an hour in the group west of the Mississippi, from Kansas and Missouri north to the border, from 25 to 35 ct. an hour in the Mountain States; and around 42 ct. an hour in the group composed of Texas, Louisiana, Arkansas and Oklahoma, where considerable work was done.

In some of the southern states road work can proceed throughout the year without serious interruption, and in other states grading and hauling of materials can be done, particularly if it is an open winter. In the states of the northern Mississippi Valley, a good deal of gravel road has been built in recent years by hauling the gravel over the frozen roads, dumping it on the roads, and waiting until warm weather to do the finishing work.

Road Marking and Signing in Wisconsin*

By N. M. ISABELLA†

The marking and signing of the state trunk highway system has done more for Wisconsin's reputation as a road state than any other activity. In the past few years we have built several hundred miles of various types of road but have not received any comment out of the ordinary by so doing. We have now marked our system for the fourth year and are about to begin the fifth season under the state trunk highway law which was passed in 1917. We have received compliments from all the various states and from the many hundreds and thousands of tourists that come to our state during the summer months. There are probably two outstanding reasons why Wisconsin ranks among the first in this matter of highway marking, (1) because Wisconsin was undoubtedly the first state in the Union to adopt a uniform system of marking through the state and (2) because Wisconsin is one of the leading tourist states in the Central West, and due to the fact that many out-of-state people come to this state during the summer months they have been able to enjoy their vacations by traveling about our state with ease and comfort due largely to the marking of our state trunk highway system.

We believe most of the counties have received letters such as we receive from day to day complimenting Wisconsin on its maintenance and marking systems. There is no question but what we are regarded as one of the leaders from the standpoint of maintenance and trunk highway marking. Several nearby states have already adopted systems of marking and maintenance, and while they have patterned somewhat after Wisconsin, will undoubtedly develop new ideas and will give us considerable competition for our standing among the states in highway work.

As stated before, we are entering the fifth season in which we have marked and signed our trunk highway system, and while things should be thoroughly well in hand and worked out to a great degree of refinement, we find that several of the counties have failed to keep up their marking. They have thereby left a weak link in the chain, as an old saying goes, "A chain is as strong as its weakest link," the natural deduction would then be that our marking is just as good as is our poorest marked county in the state. Some of the counties have gone at this matter of marking and signing in a good business like way and have started in ample time so that they finished their markings before the beginning of the tourist season. Others have let it drag along and have paid little or no attention to the renewal of the markers in their counties and in some cases they have done the work during the rush of the tourist season, thus causing a great deal of inconvenience to the traveling public and making the work cost considerably more than if it had been done prior to or after the tourist season.

We have also noted in our travels about the state that some of the county commissioners and the patrol superintendents have been out trying to do the marking in their counties. We do not believe this good business. If there is any commissioner in the state that has not enough work outside of marking and signing to keep him busy, that county should not have a commissioner. We believe that the Commissioner's time can be devoted to things other than actually going out and mark and sign the highways in his county. On the other hand, he probably cannot do it as quickly as a trained painter.

(a) First of all, white bands must be painted on the telephone poles and on culvert end walls and on the ends of bridges and the triangle should be stenciled on after the white band has dried.

(b) The plan suggested by the Highway Commission in regard to the number of markers is this: We believe that there should always be a marker in sight when driving on the state trunk highways, whether it be on the mile post, culvert end wall, on a bridge or a telephone pole does not matter—just so that a marker is visible at all times.

(c) All mile posts should be repainted.

(d) Many of our old direction signs will have to be repainted, due to the fact that they have become dirty and the painting is somewhat obscure on them.

(e) There should be sufficient R's and L's and they should be placed near enough to the turns so that they are plainly visible to the traveler.

(f) Posts should be placed at the ends of old culverts and should be painted white when painting the guard rail along the highway.

(g) All detours should be properly marked and should have more markers than the regular trunk highway.

(h) We should have danger signs near all railroad crossings, at bad curves and at bad hills. These danger signs should be placed fairly close to the point of danger; that is, we do not believe that they should be any further than 150 ft. or so from the danger point.

That covers briefly the main points to be looked after in this matter of marking and signing.

The following are a few of the things that we have noticed in traveling over the highways and believe that we can improve upon considerably:

(a) In some counties the white bands have been painted on the telephone poles, leaving the old triangle of the previous year as it was, thus making a nice white band and leaving a dark, dirty looking triangle on the posts. This should be discontinued.

*Paper presented at Eleventh Annual Road School of the Wisconsin Highway Commission.

†Assistant Maintenance Engineer, Wisconsin Highway Commission.

(b) Again in some of the other counties, instead of painting over the old band, they have placed a new white band either above or below the old one and have left the old one as it was. This is not good practice.

(c) There have been an insufficient number of markers, especially near cross roads, and the R's and L's have been very confusing in some cases. One of these I have in mind is where a left turn is made and before coming to the turn the letter (L) is on the nearest pole to the turn. Then after you make the turn the first pole shows the letter (L) again. On the opposite side, of course, it has the letter (R). We do not believe it good business to place the letter L or R at any point beyond the turn.

(d) We have noted that on the Patrolmen's signs the names of the first patrolmen on the trunk highway system still remain on these signs, but as a matter of fact there have been two or three patrolmen on some of the sections since the original one. Also, in one or two cases we have noted that the commissioner's name has not been kept up to date on the county line signs. It would seem that a comissioner would have pride enough to have this matter straightened out at least.

(e) In some cases where one trunk highway commences at a point off another trunk highway it seems to be the practice in some counties to put a marker back a couple or three hundred feet before coming to the junction of the two trunk highways, indicating that Trunk Highway No. ..... turns left or right, as the case may be. In many cases the numbers of the trunk highways are very much alike, such as 16 and 18, and if a driver is not especially cautious he will turn left on the highway which just begins at the intersection instead of going on the highway he originally intended to follow.

(f) Occasionally we have had an opportunity to visit some of the county machinery sheds and shops and have found that many of the direction signs that were sent to them to be erected have not been erected to date. This is quite an expensive proposition to have signs already paid for and lying idle in a machine shed.

(g) There has been a tendency to be somewhat careless in the care of mile posts and direction signs during construction work.

(h) In one case last summer I had occasion to pass through a county that was just doing its marking and found that the stencils on the entire trunk highway through the county had been covered up by the new white band and there were no indications to tell what trunk highway it was. We believe that a few stencils should be left here and there so that the traveler may know what trunk highway he is traveling on.

(i) In some cases the workmanship has been very poor, the bands having been put on in a very ragged manner.

I wonder if it has ever occurred to you or if you have ever thought whom we are marking the system for. If we study the situation we find that one in about every eight people in the state own a car. They certainly do not stay around their home circles but travel about the state as much as they can during their vacation periods. We have also a second class that travels our highways, namely, the tourists from other states. It has been said by some of the men connected with highway work that we are building and maintaining highways for people of other states, due to the fact that we have such a great tourist traffic during the summer, and that this marking and signing is purely for the tourist traffic. I wonder how many have stopped to think what this tourist traffic means to the state of Wisconsin. Just to give you an idea of what happens in this state during the summer in the matter of tourist traffic, I will give you the following figures: For the past two or three seasons we have taken traffic census at 60 different points on the state trunk highways in the state. During the season of 1921 this census was taken twice a month. During the week end of July 4, 1921, there were registered at these 60 different points upward of 15,000 foreign cars. We may assume that there were a few duplications but we can also assume that there were several hundreds or thousands of foreign cars which we did not count at all, and we believe that 20,000 foreign cars on that date would be a very conservative estimate. The average number of persons per vehicle statistics have shown is above three, thus making a total of 60,000 people, or more than come in on these 20,000 tourist cars. I believe we can safely assume that each one of these cars stayed in this state on the average of three days, and that each person spent $10 during his three-day stay in this state. That would amount to $600,000 of out-of-state money left in Wisconsin during a period of three days. Is this not a business that is worth catering to? Can we afford to disregard this class of people? We certainly can not, and if we mark and sign our system for no one else but for the tourist traffic, we would be amply repaid for our trouble and expense. The cost of marking the system in 1921 was approximately $25,000. Is this not a small amount of money compared to the money left here by the tourists during the summer months? However, our local people do considerable traveling right in Wisconsin and whatever we spend in the matter of marking and signing is a very small item compared to the great comfort and satisfaction the two and one-half million people of this state receive in traveling over our state trunk highway system.

County Trunk Markings

The Wisconsin Highway Commission is very desirous of cooperating with the counties to the end that they get uniform markings on their county trunk systems. The counties have realized that marking the state trunk highway system was a very good thing and

have now adopted a system within their counties. There is apt to be confusion in the markings where a highway leads from one county into another unless there is uniformity in the marking, and we are at the present time trying to work out a system whereby we can show the roads going from county to county marked with the same letter. This will be available before the marking season starts and if there are any questions along this line we would be glad to hear from you on that matter.

Detours

Detours are the necessary evils in highway transportation. There are many places where the travel may drive through the construction work but there are also a great number of cases where travel is obliged to detour. In detouring, a traveler must necessarily go further to get to his destination. That is one reason why detours should be marked even in a better manner than the state trunk highways are marked. Before any road is closed the detour should be properly marked and proper barricades be placed at the ends of the construction work. By proper barricades I do not mean an ordinary saw horse, but something that is firm and something that will attract the notice of the traveler so that he will not drive through the construction. One of the reasons for the average traveler going astray on our detours is attributed to the fact that detours as a general rule are not in as good condition as are the regular trunk highways and for that reason the driver pins his eyes on the road rather than looking for the markers and thus goes astray. When we realize that we are making the traveling public go considerably out of their way in traveling a detour, we should make up for it in having a well marked and well mantained detour. I have in mind a stretch of road that was closed this past season for 5 mi. and which necessitated a detour of a little over seven miles. The highway was a fairly heavily traveled one and was closed for four months, or 120 days. The average traffic over this highway during the summer season is very close to 1,000 vehicles, but we can assume 800 for a conservative figure. The detour being 2 mi. longer than the regular road and the road being closed for 120 days and the road having a traffic of 800 vehicles per day, we have a total of 192,000 mi. of extra travel which we have forced upon the road users. Figuring that it costs 12 ct. per mile, that detour has cost the traveling public $23,000, saying nothing about the extra time that it has taken them to make the two extra miles. The cost of marking such a detour would be considerably less than $100. Is it not fair to the traveling public that we spend this small sum in order to offset the additional mileage caused by the detour?

Plans Should Be Made Early

There are a few things which we must consider in the closing of a road for construction. First of all after the work has been located you should plan your detours well in advance of the construction season. In other words, plan them now, before you close the trunk highway. If the detour needs any improvement do it before the main road is closed.

I have mentioned one particular detour which I had in mind but when you figure that there are upwards of 200 detours on the state trunk highway system alone during the construction season this matter of detours is a very serious one and a thing that costs the traveling public a considerable amount of money, and we have to meet them half way in having the detours well maintained and well marked.

Plans for 1922

We are going to insist on a more thorough marking system in Wisconsin this year than ever before. There will be additional direction signs to be placed, also signs at the intersections of state trunk highways with county trunk highways. There will also be signs placed at streams, lakes, parks, springs, camp sites, etc. There has been a great demand for these types of signs and they will surely be appreciated by the users of the highways. As mentioned before in my talk, a great many of our present direction signs will have to be repainted and a great number more added to the system at various places. It is proposed to let a contract on a yearly basis to some painting concern to have this work done. The plan to be followed will be somewhat like this: Where a sign must be renewed, the engineers from the division office will make a sign copy and send it to the painting company and they in turn will send the new sign which will be erected by the division office. The one main reason for having one company handle this matter of painting is to get uniformity in the work, and undoubtedly will be much simpler to handle from a central plant than to have various companies through the state do the work.

INDIANA COMMISSION RECEIVES MANY BIDS

The large number of persons interested in the recent letting of four projects in Indiana, totaling about 40 mi. of road, forced the State Highway Commission to use the Senate Chamber for opening the bids. At the same time, one hundred bids for the construction of 18 bridges were opened and a number of bids were presented for lubricating oils and greases and 700,000 gals. of gasoline and kerosene.

"DUMORITE" MEETS REQUIREMENTS IN FIELD

Reports from various parts of the country show that "Dumorite," the new explosive recently put on the market by the Du Pont Company is effecting reductions in blasting costs amounting to one-third and more. Statements from users tend to show that, in quarry, farm blasting, and other open work, the new dynamite is living up to the statements made concerning it at the time it was developed.

EFFECT OF MOISTURE ON CONCRETE

After conducting a number of extensive experiments on the effect of moisture upon the expansion and contraction of plain and reinforced concrete, Torata Matsumoto, a graduate student at the University of Illinois, draws the following conclusions:

1. Concrete expands when it absorbs moisture and contracts when it is dried. Concrete of a 1:2:4 mixture is likely to contract during hardening as much as 0.05 per cent in an ordinary structure.

2. Contraction of concrete by the loss of moisture causes stress in the concrete when it is restrained by an external force. The amount of this stress is not as small as is generally supposed.

3. The shrinkage stress caused in the steel in reinforced concrete may reach the usually accepted working stress of steel when the amount of reinforcement is less than 1.5 per cent.

4. The shrinkage stress developed in 1:2:4 concrete may reach the ultimate tensile strength of the concrete when the amount of reinforcement is greater than 1.5 per cent. With richer mixtures the increase in shrinkage stress may be relatively greater than the increase in ultimate strength.

5. The greater the percentage of reinforcement the greater the tensile stress that may develop in the concrete, and concrete having a higher percentage of reinforcement than 1.5 per cent. is likely to have cracks formed unless proper provision is made.

6. In reinforced concrete out of doors, subject to alternate wet and dry conditions, cracks may readily be formed under the repeated stress which is nearly equal to the tensile strength of the concrete.

7. Reinforced concrete does not appear likely to be a durable material in a place where a corrosive influence on steel, such as sea air, is active, unless proper protection against the formation of shrinkage cracks is made.

8. It is suggested that the prevention of shrinkage stress in concrete might be accomplished in two ways, either by finding a cement giving less expansion and contraction, or by the use of a perfect waterproofing treatment.

9. It may be expected that an integral waterproofing compound might lessen the change of volume for a short time, but it would not prevent the final diffusion of moisture with consequent change in volume.

Commissioner Sisson of the New York State Highway Department has requested auto truck owners throughout the state to load their trucks to one-half of their rated capacity for the next few weeks during which the improved highways will be undergoing unusual strain due to frost action and excessive moisture.

Erie County, Pennsylvania, will float a $3,000,000 bond issue for road purposes, according to a resolution just passed by the county commissioners.

DATA ON ROAD CONSTRUCTION TO BE PUT IN USABLE FORM

A great deal of valuable data on highway construction are soon to be made available to all persons connected with highway development by the Bureau of Public Roads. In its supervision of large appropriations by Congress for federal aid road construction, the bureau has assembled complete records of contract prices for all types of roads in all sections of the country since 1916. In addition, engineers of the bureau operating in each of the 48 states report monthly on labor and material used on jobs inspected by them.

To put this information in the most usable form statistical machinery has been installed and the work so arranged that a small force can make available a great variety of information at a small percentage of the cost of such work when done by hand. The data assembled will consist of monthly reports on the status of federal aid work, prices paid for labor and contractors' bids for new work in all sections of the country. From time to time reports covering a large volume of work will be made on costs of various types of surfacing and grading, percentages of various types of roads built, proportion of total cost which goes into grading, surfacing and other items of construction, together with any other information for which there may be need.

EIGHTEEN STATES TAX GASOLINE

Of the eleven states whose legislatures have convened this year or are still in session, four have enacted a gasoline tax. They are Maryland, Louisiana, South Carolina and Mississippi. Bills for a gasoline tax are still pending in Massachusetts and Rhode Island. In all of these cases, as has hitherto been the custom, the gasoline tax has been enacted in addition to the customary motor vehicle registry and general license fees. The gasoline tax in these four states is one cent a gallon.

These recent additions give a total of eighteen states in the Union which collect fees on gasoline purchased within their borders. The fourteen which had the law last year are Arizona, Arkansas, Colorado, Connecticut, Florida, Georgia, Kentucky, Montana, New Mexico, North Carolina, Oregon, Pennsylvania, South Dakota and Washington. The rate in every case is one cent a gallon, except in Oregon, where the fee is two cents. A gasoline fee bill was introduced into the recent New York Legislature, but in view of the fact that registry fees were materially increased on both passenger cars and trucks no serious effort was made to pass it.

The Ohio State Highway Commission opened bids for the construction of various hard surface highways at a meeting held March 31, when it received figures from approximately 500 bidders.

MEETINGS

Calendar of Coming Meetings

May 12—National Highway Traffic Association—Annual meeting, Automobile Club of America, New York City. Secretary, Elmer Thompson, 247 West 54th St., New York City.

June 4-6—American Association of Engineers—Annual convention, Salt Lake City, Utah. Secretary, C. E. Drayer, Chicago, Ill.

June 13-16—Canadian Good Roads Association—Ninth annual convention, Victoria, B. C. Secretary-treasurer, George A. McNamee, Birks Bldg., Montreal, Canada.

June 26-July 1—American Society for Testing Materials—Twenty-fifth annual meeting, Atlantic City, N. J. Secretary, C. L. Warwick, Engineers' Club Bldg., Philadelphia, Pa.

Oct. 9-13—American Society for Municipal Improvements—Annual convention, Cleveland, O. Secretary, Charles Carroll Brown, Valparaiso, Ind.

NATIONAL HIGHWAY TRAFFIC ASSOCIATION

The annual meeting of the National Highway Traffic Association will be held at the Automobile Club of America, 247 West 54th Street, New York City, on Friday, May 12. The afternoon and evening sessions will be devoted to a consideration of the reports committees:

Afternoon Session, 2 p. m.

Report of National Committee on "Uniform Highway Signs," Chairman, Elmer Thompson, Secretary, Automobile Club of America.

Report of National Committee on "Traffic Capacity and Widths of Highways Outside of Municipalities," Chairman, Herschel C. Smith, Assistant Professor of Highway Engineering and Highway Transport, University of Michigan.

Report of National Committee on "Status of the Construction of Highway Curves and Recommended Practice to Increase Safety to Traffic," Chairman, H. Eltinge Breed, Consulting Highway Engineer, New York City.

Report of Executive Committee on "Highway Improvement Creed" of the National Highway Traffic Association.

Informal Dinner, 6 p. m.

An informal dinner, at $1.50 per cover, will be served in the Grill Room of the Club at 6 p. m. The public is cordially invited to attend the dinner. Reservations for the dinner should be sent to Secretary, Elmer Thompson.

Evening Session, 8 p. m.

Report of National Committee on "Regulations Governing Speeds, Weights and Dimensions of Motor Trucks and Trailers," Chairman, George H. Pride, President, Heavy Haulage Company of New York City.

Report of National Committee on "License Fees and Motor Vehicle Taxation," Chairman, Henry G. Shirley, Roads and Sanitary Engineer, Baltimore County Roads and Sewerage Department.

Report of National Committee on "Highway Transport Franchises," Chairman, F. W. Fenn, Secretary, National Motor Truck Committee, National Automobile Chamber of Commerce.

Report of National Committee on "Highway Transport Clearing Houses," Chairman, Tom Snyder, Secretary, National Association of Commercial Haulers, Indianapolis.

PERSONAL MENTION

R. E. Spear, City Engineer and Assistant City Manager, Ambridge, Pa., has resigned.

George L. Burton has been re-elected chairman of the New Jersey State Highway Commission.

John W. Reid has been appointed city engineer of Detroit, Mich., succeeding Clarence W. Hubbell, resigned.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912, of "GOOD ROADS," published weekly at New York, N. Y., for April 1, 1922.

State of New York, County of New York, ss:

Before me, a Notary in and for the state and county aforesaid, personally appeared F. W. Baker, who, having been duly sworn according to law, deposes and says that he is the Business Manager of "Good Roads," and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher—The E. L. Powers Co. (Inc.), 11 Waverly Place, New York, N. Y.

Editor—E. L. Powers, 11 Waverly Place, New York, N. Y.

Managing Editor—C. A. Lewis, 11 Waverly Place, New York, N. Y.

Business Manager—F. W. Baker, 11 Waverly Place, New York, N. Y.

2. That the owners are:

E. L. Powers Co. (Inc.), 11 Waverly Place, New York, N. Y.

E. L. Powers, President and Treasurer, 11 Waverly Place, New York, N. Y.

F. W. Baker, Secretary, 11 Waverly Place, New York, N. Y.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent. or more of total amount of bonds, mortgages, or other securities are: None.

4. That the two paragraphs next above giving the names of the owners, stockholders, and security holdiers, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company, but also, in cases where the stockholders or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than of bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is: (This information is required from daily publications only.)

F. W. BAKER, Business Manager.

Sworn to and subscribed before me this 7th day of October, 1921.

HENRY L. MILLER,
Notary Public.
(My commission expires March 30, 1923.)

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

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Volume LXII. April 19, 1922 Number 16

TABLE OF CONTENTS

*The Selection and Proportioning of Sands for Sheet Asphalt Paving Mixtures. By Prevost Hubbard . 219

*Highway Researches and What the Results Indicate. By A. T. Goldbeck 223

The Osterman Memorial 230

Federal Aid Bill Reported in House 231

New Machine for Placing Concrete 231

Highway Costs in Indiana 231

Good Roads in Delaware 231

County to Protect Its Paved Roads 231

Colorado to Build Road to Summit of Mount Evans 232

Highway Engineer Awarded Damages 232

Hearing on Elimination of Grade Crossings in Nevada 232

Kentucky Abandons Use of Convicts 232

EDITORIALS:

Sand for Asphalt Pavements 227

Traffic in the Spring 227

Convict Labor 227

Caring for Tourist Traffic 227

MEETINGS:

Calendar 232

PERSONAL MENTION 232

*Illustrated Article

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Vol. LXII., NEW YORK, N. Y., APRIL 19, 1922 No. 16

The Selection and Proportioning of Sands for Sheet Asphalt Paving Mixtures*

By PREVOST HUBBARD†

Control of the character and grading of sand used in the preparation of wearing course mixtures is a very important factor in the construction of sheet asphalt pavements. Ordinarily sand constitutes from 70 to 80 per cent of the weight of such mixtures and under compression during construction the sand grains are crowded together so as to form the skeleton structure or frame work of the wearing course. These grains take most of the wear of traffic and should therefore be of hard sound material, such as quartz. They should also be clean and free from coatings of any sort and preferably rough surfaced so that the asphalt cement will adhere firmly to them. With regard to the actual size and grading of the sand grains best suited for such work much more has been learned from experience than from theory. Theory and practice however agree on the desirability of using sand with relatively low percentage of voids when the grains are in intimate contact. Experience has shown that when certain grading requirements are met the percentage of voids may be kept within satisfactory limits without sacrificing other necessary characteristics, such as ability to carry mineral filler. Such requirements are therefore usually included in specifications.

The presence of an appreciable amount of grains coarser than 10 mesh brings the mixture into another class of construction known as asphaltic concrete which will not be considered in this article. Sand grains passing the 200 mesh sieve are considered undesirable because they tend to produce a mushy mixture, and limestone dust or Portland cement are preferentially used to supply all of the very fine mineral matter which is necessary to fill the tiny voids in the sand aggregate. The first requirement is therefore that the sand shall all pass the 10 mesh sieve and the second that not more than 5 per cent shall pass the 200 mesh sieve. The first requirement can be met without difficulty even if the original product has some material larger than 10 mesh, by passing it over a revolving screen, with openings of suitable size, which is located over the storage bins of the paving plant. If the second requirement is met nearly all of the material passing a 200 mesh sieve will be blown out of the sand during its passage through the drier so that for all practical purposes the sand specified may actually be considered as all passing the 10 mesh and retained on the 200 mesh sieve.

Having quite definite maximum and minimum limits for the sand as a whole it is also most convenient in paving work to calculate the relative weights of the various size grains upon a percentage basis which will show a total of 100 per cent passing the 10 mesh and retained on the 200 mesh sieve. Standard sieves are used for this purpose, 10, 20, 30, 40, 50, 80 and 100 mesh, and each percentage calculated represents a size which passes one sieve but is retained upon the next smaller sieve. There are therefore seven such individual sizes the allowable percentage limits of which are included in paving specifications. The following table shows the limits taken from specifications of the Asphalt Association, which are typical of good practice.

Sand Grading for Sheet Asphalt

Passing	Retained on	Per cent Individual Sizes	Per cent Group Sizes
10 mesh	20 mesh	3 to 15	
			Coarse
20 mesh	30 mesh	4 to 15	14 to 50
30 mesh	40 mesh	5 to 25	
40 mesh	50 mesh	5 to 30	Intermediate
			30 to 60
50 mesh	80 mesh	5 to 40	
80 mesh	100 mesh	6 to 20	Fine
			16 to 40
100 mesh	200 mesh	10 to 25	

The Three Group Method of Grading

In this table it is seen that besides the limits for each individual size the sand grains are divided into

*Paper presented at annual convention of the American Road Builders' Association.

†Chemical Engineer, The Asphalt Association.

three main groups which may be designated as coarse, intermediate and fine. The coarse group consisting of 10, 20 and 30 mesh particles all of which are retained on the 40 mesh sieve, is allowed to vary between 14 and 50 per cent. Taking an average of 32 per cent an approach toward the minimum limit is desirable for heavy traffic which tends to crush the large grains more readily than the fine. For relatively light traffic however a higher percentage of coarse grains is not only permissible but will produce a mixture less likely to crack by contraction owing to the thicker films of asphalt cement which it carries. Under heavy traffic any tendency to crack is largely overcome by the kneading action of the traffic itself.

The fine group, consisting of 80 and 100 mesh particles which are retained on the 200 mesh sieve, serves to fill the large voids in the combination of coarse and intermediate groups and enables the mixture to hold, evenly dispersed, the mineral filler which is needed to fill the very small voids and give stability to the pavement. When the percentage of coarse group is relatively high the percentage of fine may be relatively low and vice versa.

The intermediate group, consisting of 40 and 50 mesh particles which are retained on the 80 mesh sieve, appears to serve somewhat as a pivot for the coarse and fine groups. An average of about 45 per cent will serve equally well for use in light and heavy traffic mixes. In the former however the sand may carry as high as 60 per cent and the latter as low as 30 per cent of the intermediate group.

When the fact that a certain amount of each individual size is specified it is seen that the percentage limits for each size are quite broad. As a matter of fact if in each group the individual sizes are about equally proportioned a very satisfactory grading results. The group percentages are therefore the most important and are first considered when selecting sand for sheet asphalt construction.

The use of local sand for paving work is desirable not only from the standpoint of convenience but as a matter of economy. As has been stated sand constitutes from 70 to 80 per cent. by wieght of the paving mixture and a high freight rate on this constituent greatly affects the cost of the finished pavement. It frequently happens, however, that no single local sand can be found which meets specification requirements and when this happens it may become necessary to mix or combine two or more available sands of known mesh composition in order to produce an acceptable product. In such a case it becomes necessary to ascertain in what proportions the sands should be used to give the desired grading. This is ordinarily done by a tryout method or by a lengthy but simple mathematical calculation. The fact that there are three main groups to be considered and that the sum of these groups equals 100 per cent. makes it possible to utilize the triaxial diagram for quickly and accurately ascertaining the most suitable proportions, although to the best of the writer's knowledge the diagram has not heretofore been used for this purpose.

The Triaxial Diagram

For those who are not familiar with the triaxial diagram it may be said that it consists essentially of an isosceles triangle in which, as is well known, the perpendicular distance from each base to its opposite apex is equal. These perpendicular distances may therefore serve to represent 100 per cent. of anything that the base lines stands for. The perpendicular distances may be divided in any convenient way such as hundredths and if lines are drawn through such divisions parallel to the base lines the large triangle is divided into a large number of small isosceles triangles as shown in the accompanying illustrations. It is a simple geometrical proposition to prove that for any point within the area of an isosceles triangle, the sum of the perpendicular distances to each side is equal to the perpendicular distance from any side to its opposite apex. If the distance from base to apex represents 100 per cent. it is evident that the sum of the perpendicular distances from a point within the triangle to each side must also equal 100 per cent. When there are only three constituents of a substance it therefore becomes possible to plot the percentage composition of each constituent by means of a properly located point within the triangle.

In Fig. 1 each side of the large triangle serves as a base line for one of the three groups of sand grains previously discussed. The distance between each side

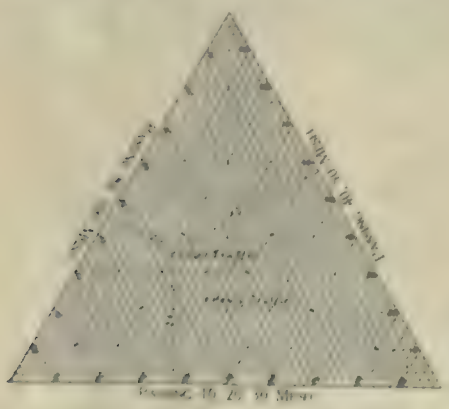


FIG. 1

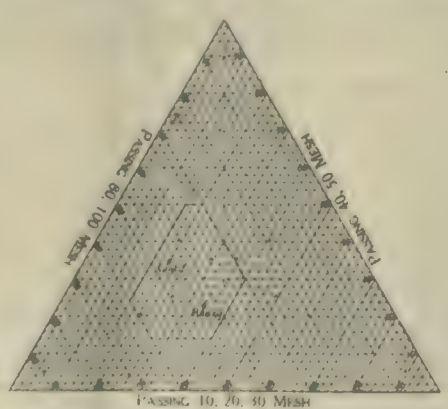


FIG. 2

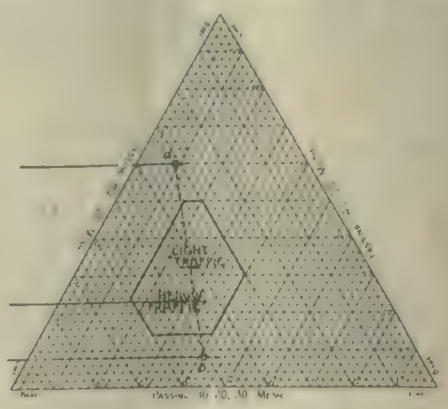


FIG. 3

and its opposite apex is divided into 50 equal spaces by lines parallel to the base line and the distance between each line and its neighbor therefore represents 2 per cent. Within the area of the triangle the two dots surrounded by circles represent the composition of ideal sands for light and heavy traffic which conform to the following grading in so far as the three group sizes are concerned.

Passing	Light Traffic Per Cent	Heavy Traffic Per Cent
10, 20, 30 mesh	35	23
40, 50 mesh	45	43
80, 100 mesh	20	34

The dotted lines connecting the light traffic and with the three sides of the triangle illustrate how the position of the sand has been located to show the percentage composition given above. Fig. 2 is exactly the same as Fig. 1 except that the dotted lines have been left out and a shaded area inserted to represent the percentage limitations for the three groups as covered by the specification requirements given in the first table. It is at once evident that any sand which conforms with the specification limits will fall within this shaded area if its percentage composition is plotted. On the other hand if the sand lies outside of the shaded area it does not conform with the specifications and should only be used in combination with some other sand.

Problem 1.—Use of the Triaxial Diagram in Proportioning Two Sands

Suppose two sands, "a" and "b" are available neither of which meet specification requirements and it is desired to ascertain if these sands may be combined so as to conform with specifications and if so the most suitable proportions in which they should be combined. For the sake of illustration it may be assumed that these sands show the following grading.

Group	Per Cent A	Per Cent B
Passing 10, 20, 30 mesh	60	8
Passing 40, 50 mesh	31	51
Passing 80, 100 mesh	9	41
Total	100	100

If these two sands are plotted on the diagram it is found that their locations as shown by points "a" and "b" respectively in Fig. 3 lie outside of the specification area. The grading of all possible combinations of these two sands is then illustrated by means of a straight line drawn between these two points. If their locations had been such that the connecting line did not cut the specification area it would have been impossible to combine them in any proportions so as to meet specification requirements. In the example given, however, it is seen that the connecting line passes through the specification area and that a rather wide range of combinations will prove satisfactory. It is therefore possible to so proportion the sands as to obtain a grading at any point on the connecting line within the specification area. If for example it is desired to produce a grading as close as possible to the ideal heavy traffic sand the location of such grading would be indicated on the diagram at point "c", the actual grading of this combination being as follows:

Passing 10, 20, 30 mesh	23 per cent
Passing 40, 50 mesh	45 per cent
Passing 80, 100 mesh	32 per cent
	100

The portions required to produce this grading is, moreover, directly indicated by the relative distances to point "c" to points "a" and "b." Thus, if the distance from "c" to "a" is twice the distance from "c" to "b" then two parts of sand "a" to one part of sand "b" will give the grading shown by point "c." The exact proportions may be quickly and conveniently ascertained by first drawing parallel lines through points "a," "b" and "c." In doing this any convenient base line of the diagram may be used as a guide. In Fig. 3 the 10, 20, 39 mesh base line has been used for this purpose but either of the other base lines would have served equally as well although it is desirable to have the parallel lines as far apart as practicable. As the lines which were drawn are parallel it follows that the relative distances between them are exactly the same as the relative distances between points "a," "b" and "c" through which thy pass. These lines may, therefore, be used equally well to determine exact proportions.

If we now forget the diagram itself, it will be found that four lines have been plotted as shown in Fig. 4. By means of a special proportional parts measure also shown in the figure it becomes possible to read off at once the exact proportion in which sands "a" and "b" should be combined to produce the grading represented by "c." It will be noted that the two end divisions on this measure are lettered A and B, respectively. In using the measure division A should first be placed at any suitable place on the solid line passing through point "a" and then rotated until division B rests on the solid line passing through point "b." It is seen that the solid line passing through point "c" intersects the measure at a division which shows the proportional parts in columns A and B to be 7 and 17 respectively. In other words 7 parts of sand "a" and 17 parts of sand "b" will give the grading of the combination represented by point "c."

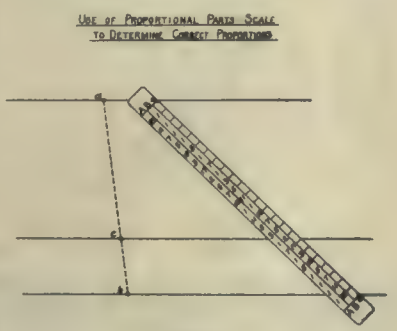


FIG. 4

Problem II.—Use of the Triaxial Diagram in Proportioning Three Sands

If the use of the triaxial diagram for proportioning two sands is thoroughly understood its use in proportioning three sands becomes a very simple matter.

In the following example it will therefore be assumed that the reader has mastered Problem I.

Suppose three sands, "a," "b" and "b′ " are available no two of which can be combined to meet specification requirements, and it is desired to ascertain if the three sands may be combined so as to conform with specifications and if so the most suitable proportion to use. As an illustration, it may be assumed that these sands show the following grading.

Group	Per Cent a	b	b′
Passing 10, 20, 30 mesh	74	2	18
Passing 40, 50 mesh	23	80	8
Passing 80, 100 mesh	3	19	74
Total	100	100	100

The location of these three sands in the triaxial diagram is shown at points "a," "b" and "b′ " in Fig. 5. It is seen that none of the lines connecting these points pass through the specification area so that no two sands can be combined so as to meet the specifications. By combining sands "a" and "b," however, and grading may be obtained on line 2, "b" and if all such possible mixtures of "a" and "b" are considered it is further seen that sand "b′ " may be combined with such mixtures so as to produce all gradings falling within triangle "a," "b" and "b′." As the specification area falls within this triangle it is therefore possible to combine the three sands so as to obtain any desired grading within the specification area.

Now suppose it is desired to obtain the ideal heavy traffic grading in the specification area we may draw a line from point "b′ " through the ideal heavy traffic grading and continue it until it intersects line "a-b." The point of intersection may be lettered "c." The determination of the proportions of sands "a" and "b" to produce "c" may be readily determined as described under Problem I. and if this mixture is then considered as a single product the proportions of this mixture is then considered as a single mixture with sand "b′ " which will give the ideal heavy traffic mixture may be determined in a similar manner.

Fig. 6 illustrates the preliminary steps necessary to determine these proportions with one set of parallel lines drawn through points "a," "b" and "c" and second set of parallel lines drawn through "c," "b′ " and the ideal grading. Fig. 7 shows these parallel lines with the diagram eliminated the lines being lettered (a), (b), (c), (a′), (b′), and (c′). Now suppose the proportional parts measure shows that one part of "a" and two parts of "b" will produce "c." Further supose it is found by using the measure that two parts of this mixture now called sand "a′ " and one part of sand "b′ " will give the ideal grading now called "c′." The direct proportions of sands "a," "b" and "b′ " would be obtained by multiplying the parts of "a" and "b" by the parts of "a′ " and multiplying the parts of "b′ " by the sum of the parts of "a" and "b," as follows:

	Parts			Direct Proportions	
a	1	a′	2	a 1 x 2	2
b	2			b 2 x 2	4
Total	3	b′	1	b′ 3 x 1	3
				Total	9

The Proportional Parts Measure

For use with the triaxial diagram a proportional parts measure may be devised with any convenient scale of divisions. For most purposes the "a" scale showing all common proportions not exceeding a total of 12 parts to the mixture will be satisfactory. For the sake of convenience when actually mixing sands it is desirable to have as few total parts as possible and it will often be found that without creating much change in the grading of a mixture one set of proportions may be as good as another. In such cases the simplest proportions should be selected. Thus, if Fig. 4 while the exact proportions of sands "a" and "b" are shown as 7 to 17 respectively it is seen that the more simple proportions of 1 to 2 or 1 to 3 are quite close. Reference to Fig. 3 will further show that either of these simple proportions is sufficiently close to the desired grading to be adopted as a matter of convenience.

It should always be remembered that the triaxial diagram takes into account only the three sand groups and that the intermediate gradings are also covered in specifications. After it has been used therefore the individual gradings should be calculated on the basis of the proportions which have been indicated in order

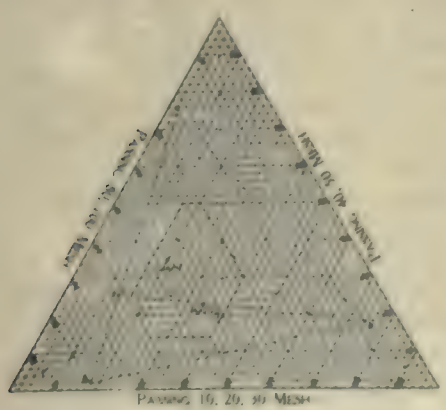


FIG. 5

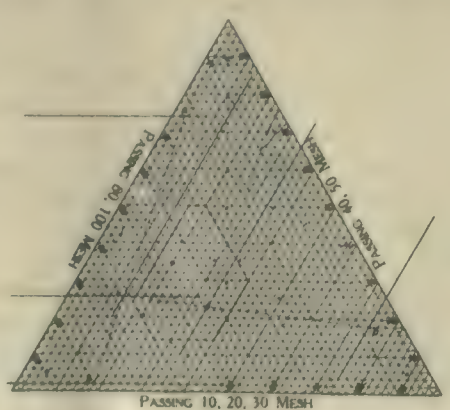


FIG. 6

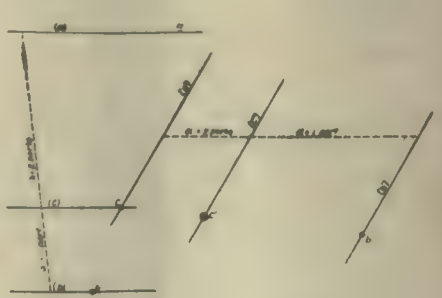


FIG. 7

to ascertain if such proportions will be entirely satisfactory. If not a slight change in indicated proportions will often be found to bring the mixture within specification limits in all respects. Of course if any individual size is missing in all of the sands the specifications cannot be met but this would be a rare exception and in most cases the proportions determined form the group gradings alone will be found satisfactory.

Field and Plant Use of the Triaxial Diagram

A triaxial diagram with a transparent cover of celluloid or tracing cloth which may be carried in an ordinary coat pocket will often prove a considerable time and labor-saving device for the contractor, inspector and engineer both when prospecting for available sands and in setting proportions for use at the paving plant. The transparent cover may be used for plotting the sand gradings and drawing the lines for use with the proportional parts measure, and when one set of determinations has been made all marks may be erased and the cover used over and over again.

If when prospecting for sands, a portable field outfit consisting of a small spring balance and set of four sieves (10, 40, 80 and 200 mesh) is used, the triaxial diagram will quickly show when suitable products have been located. To those who have not been familiar with the triaxial diagram methods here described may at first seem somewhat complicated but with very little practice it will soon be found that its use is a very simple matter and much less tedious and complicated than any method of mathematical computation.

Highway Researches and What the Results Indicate*

By A. T. GOLDBECK†

At the very outset let us inquire into the conditions which seem to be arousing high interest in road researches throughout the country, and which have led to the expenditure of thousands of dollars in construction of test specimens and test roads, ultimately to be destroyed under known conditions of traffic. In a recent paper by the Chief of the Bureau of Public Roads a very clear demonstration has been presented of the great lag in percentage of increase in expenditures for road construction, as compared with the tremendous percentage of increase in motor vehicles from 1910 up to the present time. He has shown that although the number of motor vehicles in the past decade has increased roughly eighteen hundred per cent, the increase in road expenditures has been only four hundred per cent. These are extremely vital facts for they show that the percentage of increased expenditures for road construction has sadly lagged behind the percentage of increase in the number of motor vehicles, and it would seem logical that we must expect to spend still greater sums in the future for road construction in order that our road systems may be adequate for the demands of traffic.

Any engineering project involving enormous expenditures must be based on sound engineering principles else the full proportion of those expenditures will not yield returns, for human judgment is not infallible and without adequate knowledge mistakes are made. Mistakes in policy and errors in design have led to disproportionate road revenues in the investments in highways in the future, we would be extremely unwise did we not gain every possible bit of definite and scientific information which will lead us to sound engineering design and give us the basis for sound engineering judgment. At the present time we are lacking in far too many items of cold, scientific knowledge, and efforts are being made by the Bureau of Public Roads, by several of the state highway commissions and by other agencies to gain the lacking information at the earliest possible date. The possession of this information means a saving for the taxpayer of tremendous sums of money. That alone is sufficient reason for the increasing interest in investigations, research, tests and inquiries into the problems of highway design and highway construction.

In planning the researches of the Bureau of Public

I. VIEW OF IMPACT TEST.

Roads we have had very definitely in mind that when our researches are completed we should have information which will lead to the more rational design of road systems that will serve traffic with the utmost economy. It should be emphasized that our roads should be planned not only to sustain the traffic without pre-

*Paper presented at annual convention of the American Road Builders' Association.

†Chief, Division of Tests, U. S. Bureau of Public Roads, Washington, D. C.

mature failure, but should be regarded as merely an essential part of a system of highway transportation, just as a railroad track is merely a part of a railroad transportation system. The roads, and the vehicles traveling over the roads, should be so suited to one another—not that the road surface will be most conserved, and not that the vehicles will be able to travel over them with the least possible vehicle cost,—but that ultimate transportation economy will result. In other words, we have in mind that after all, our main object should be to accomplish highway transportation with the least cost to the general public who are paying for all the items of vehicle cost and highway cost involved in that transportation. This is a most important thought and I wish to lay special emphasis on it.

Basic Knowledge Is Lacking

It will be readily understood that the maximum economy in highway transportation will only be possible after sufficient basic facts have been obtained to enable the highway engineer to say definitely that here is the proper design for the definite set of conditions at hand. Unfortunately, this basic knowledge is lacking in many important branches of highway engineering, and we have undertaken as a starting point of our investigations a series of researches bearing on the structural design of highways. I have already outlined before this congress the researches to be undertaken dealing with structural design and in order to lead you into an understanding of the results obtained, and the application of these results, it will be necessary for me to recall to your minds very briefly how a number of these investigations are being carried on. A highway pavement must be regarded as a structure acted upon by forces and just as susceptible to the principles of mechanics,—although perhaps more highly complicated mechanics—as a bridge structure. A little reflection will show that all pavements may roughly be divided into slabs of a rigid and of a non-rigid type, with a shading of one into the other. Thus, concrete and grouted brick on a concrete base are of the rigid type, sand-clay and gravel of the non-rigid type and bituminous pavements, although at times of the non-rigid type are at other times capable of resisting some bending. The scope of our experiments has been outlined in such a way that we hope to be led into rational pavement design through the establishment of the fundamental facts.

Loads on the Pavement

One of the first thoughts that struck us was, what are the loads for which a pavement must be designed? If the traffic did not move there would be a comparatively simple answer to this question, for then all we would have to do would be to use the known weights and wheel loads to the different sized vehicles. But traffic moves, and in some cases with very high velocity, and although we are approaching the ideal of smoothness on our road surfaces, nevertheless, they are still somewhat wavy and somewhat rough, with the result that there is vertical motion of the vehicles with respect to the road, and impact is thus produced by traffic on the road surface. We have made a very extensive series of investigations on the impact of motor vehicles of different sizes equipped with different kinds of special wheels and tires and running at variable speeds. We have fairly well established how much force is to be expected from the different classes of vehicles, and from this we can conclude to a certain degree what might be the relative destructive effect of these different vehicles.

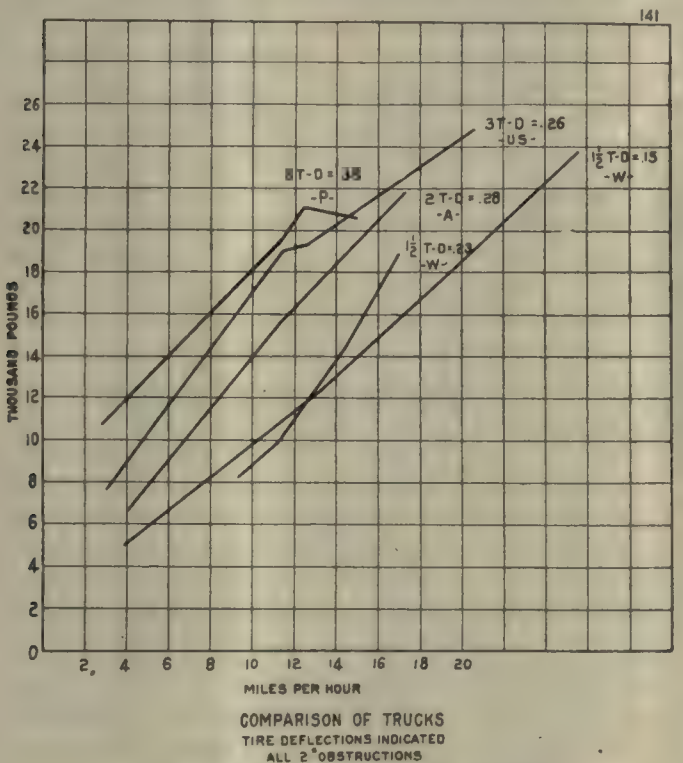
Let me recall to your minds the somewhat approximate method by which we have obtained our results. The method consisted of placing an annealed copper cylinder under the plunger of a hydraulic jack which was set below the road surface. The motor trucks were permitted to fall upon this jack when running at different speeds and falling from different heights, and they thus delivered impact to the road surface or rather to the hydraulic jack in the road surface under known conditions. The impact flattened the copper cylinder and an exactly identical cylinder was placed in a testing machine and the pressure required to flatten it an identical amount was obtained. In this way we were able to express the blow delivered by the motor vehicle in terms of pressure required to flatten the copper cylinder under the blow. Although this was approximate, by further investigations we have been able to determine very closely the error involved in this type of measurement. The detailed results of these experiments are published elsewhere. (See "Public Roads," March, 1921, and December, 1921.)

Let us look at a few typical results showing the high spots of this investigation. There is a well established law of mechanics that force is equal to mass times acceleration. This simply means that if a body is in motion and is brought to rest, the more suddenly that is accomplished the greater will be the force necessary. If a steel sledge hammer strikes a steel anvil, the sledge is brought to rest almost instantly and there is tremendous force delivered between the sledge hammer and the anvil. On the other hand, if the sledge hammer were shod with a cushion of rubber a very much longer time would be necessary to bring it to rest, and the pressure on the anvil would be very much smaller. The baseball player unconsciously makes use of this principle by drawing his hands back while catching a fast moving ball. Without going into too much detail, which may be obtained from the papers already published, the following curves will illustrate the main facts.

What effect has speed on impact? In general there is a very definite increase in impact with the speed of the vehicle, but in view of the variables of the truck design and tire equipment as well as kind and degree of roughness of the road surface, there is no definite

law of increasing impact with speed, yet speed is a very important factor in impact. However, because the lighter trucks move at a very much greater speed than the heavier trucks, the impact delivered by light trucks running at their maximum speed may be as high as that of heavy trucks at their maximum speed. Results are not yet available, though, to show whether or not this would mean equal destruction on the part of the heavy and light trucks at their maximum speeds. Fig. I illustrates this point very well.

What effect has weight of truck on impact? This depends to some extent on the design of the truck. Thus, of two trucks of equal weight, one having four wheels and the other having six wheels, the weight on the wheels of the four wheeled truck would be heavier



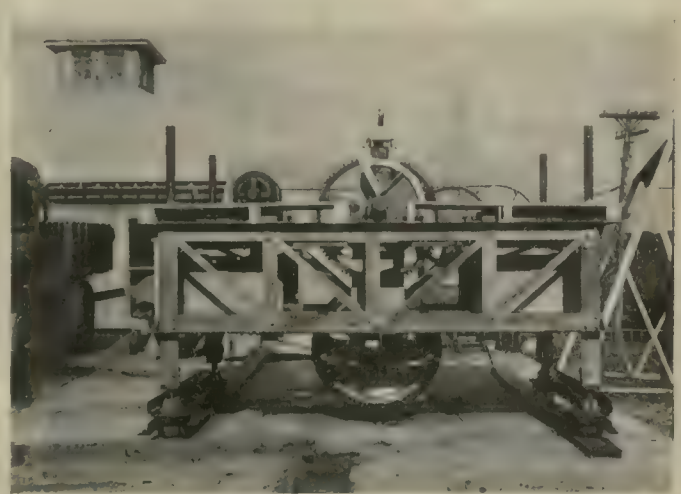
II. COMPARISON OF TRUCKS.

than that on the six wheeled truck and this would greatly increase the impact. Then too, trucks differ with respect to their distribution of sprung and unsprung weight and it seems to be established that light unsprung weight, that is, light weight beneath the springs, has the effect of decreasing the impact on the road surface. In general, however,—and Fig. I likewise illustrates this point,—for like speeds the heavier the truck the heavier becomes the impact on the road surface.

What effect have tires? Tires have a most important effect, depending upon their cushioning properties. This is self-evident and, as a rule, the better the cushioning properties of a tire the less will be the impact on the road surface. In some of our experiments we have equipped the same truck with different kinds of tires, first with solids, then with cushion tires, and finally with pneumatic tires, and Fig. II well illustrates the astounding difference in impact on the road surface. In this case a two-ton truck was used and it will be noted that when equipped with solid tires the impact, say at sixteen miles per hour, is from four to five times as much as the mere weight on the rear wheel of the vehicle. When equipped with pneumatic tires the impact is only about seventy-five per cent. greater than the static weight, and cushion tires give an intermediate effect.

These results, when carefully studied, give very strong indications that so far as conservation of the road is concerned it would be economical to require that all vehicles be equipped with pneumatic tires, but we must be practical and take into consideration the limitations of the pneumatic tire for carrying heavy wheel loads. Like investigations have involved cushion wheels of several different types, as well as a number of types of cushion tires. So far as the cushioned wheel is concerned much depends upon the design. The idea of all cushion wheels is to give extra movement of the hub with respect to the pavement surface and in so far as they accomplish this object they reduce the shock to the vehicle. Our tests, however, indicate that several types of cushion wheels do not decrease the impact delivered to the road surface, which is probably due to the heavy rim construction necessary. This by no means indicates, however, that they are not efficient in accomplishing the purpose for which they were designed, namely, that of reducing shock to the vehicle. It does indicate, though, that vehicles thus equipped may be just as destructive to the road surface as those not so equipped. On the other hand, other designs of cushion wheels do lessen the shock to the road surface. Details of these studies have likewise been published.

Other tests have included special tires and certain of these tires seem to be very effective in alleviating



III. VIEW OF IMPACT MACHINE AT ARLINGTON.

impact pressure on the road surface, although none of them are as effective as pneumatic tires. In general, the results show that under the most extreme conditions there is the possibility of obtaining impact seven times as high as the static weight on one rear wheel. The

average value is perhaps about four times that of the static weight, when the truck is equipped with solid tires. The average impact value when equipped with pneumatic tires is only about one and one-fourth times as much as the static weight. Road destruction undoubtedly is related in some degree to the impact received, and ultimately it is possible that legislation indirectly will take cognizance of this fact.

Effect of Impact on Road Surfaces

We still have under way a large series of investigations of impact on road surfaces of different types and we have completed a large series of tests on rigid pavements, involving plain concrete of different construction and brick pavements having different types

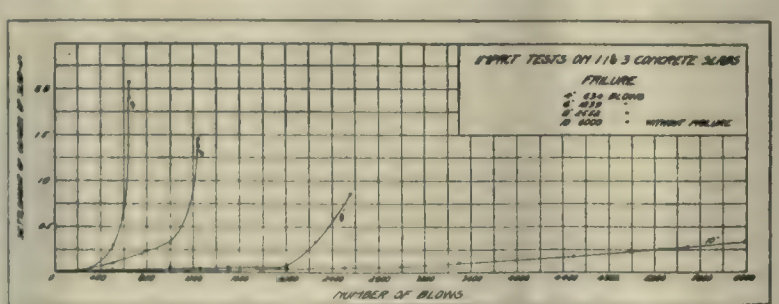
IV. GENERAL VIEW OF ARLINGTON FARM EXPERIMENTS

of fillers and different types of foundations. Details of the results thus far obtained have been published ("Public Roads," October, 1921) and the method of testing has been described before this body. But let me again briefly call it to your minds. We have built slabs of different design directly on the subgrade. The slabs are 7 ft. square. Previous studies and road tests made by us indicated that this size was sufficient to distribute the load to the subgrade. Then, too, we had in mind that if a pavement of the rigid type were to break into pieces smaller than this, failure would be considered complete, and we have worked, therefore, on the assumption that if slabs of this size are capable of resisting the impact to which they would be subjected in a pavement, the pavement would still be very serviceable.

The testing machine, it will be recalled, was designed to resemble the conditions on the rear wheel of a 5-ton truck. It consists of an unsprung weight of 1,800 lb. shod with a solid rubber tire and carrying a heavy truck spring supporting a weight of 6,000 lb. By means of the proper mechanism the entire weight is allowed to fall repeatedly on the center of the test specimen, 500 blows at ⅛ in., and 500 blows at increasing heights of ⅜ in., deflections of the slab being measured, and other careful observations taken as to the condition of the slab. I shall not burden you with the details of this test since they are covered elsewhere but will simply call to your attention the main indications.

Referring to Fig. V, there are shown curves taken in connection with the tests on concrete slabs 6, 8 and 10 in. in thickness. The point of sudden curvature indicates that a crack was formed, and ultimate failure took place soon after this. Note that it only required 640 blows to cause failure of the 4 in. slab, 1,237 blows for the 6 in. slab, 2,552 blows for the 8 in. slab, and six thousand blows were delivered to the 10 in. slab without producing failure, and it was considered that the 10 in. slab would have withstood a very large number of blows without breaking.

Referring to Fig. VI, similar curves are shown for various types of brick construction involving sand-cushion, semi-monolithic and monolithic brick on 4 and 6 in. concrete bases, and involving also bituminous filled brick on 4 and 6 in. concrete basis. It is evident that so far as resistance to impact is concerned the slab strength has great influence, and thus pavements which have greatest slab strength, very broadly speaking, will have the highest resistance to impact. Such a statement can, of course, not be taken without qualifications, for these tests were made on a medium soft subgrade, and of course the supporting value of the subgrade influences the resistance which the slab will be called upon to offer. For instance, where the subgrade is soft the slabmust be subjected to considerable bending, and must be capable of resisting this bending; whereas, if the subgrade is exceedingly hard, the load is transmitted to the subgrade without producing much bending of the road slab. Naturally on subgrades of high supporting value, slabs having lower resistance to bending can, therefore, be used than on subgrades of low supporting value. Thus far we have tested



V. IMPACT CURVES FOR CONCRETE

56 slabs, some laid on a wet subgrade and some on a dry subgrade, there being, however, not very much difference in the supportng values of the subgrades. As a result of the preceding series in which we have determined the impact values of different motor trucks, we have been able to arrive at some conclusion through analysis of the results, which throws considerable light

(Continued on page 228)

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

Founded January, 1892

E. L. POWERS
Editor

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Cable Address: Gudrodes, New York

Copy for advertisements must reach the New York office by noon on Tuesday of the week before date of issue if proofs are to be submitted.

Copy for classified and other advertisements where proofs are not required will be accepted until noon on Monday of the week of issue.

Articles by road builders are solicited. They should be short and, if possible, accompanied by photographs. Those accepted will be paid for at current rates.

Vol. LXII April 19, 1922 Number 16

TRAFFIC IN THE SPRING

During the spring, earth and gravel roads are in unstable condition and are very easily damaged by heavy traffic. Recently Commissioner of Highways Sisson of New York requested motor truck operators to load their vehicles to one-half capacity for a few weeks. That motor vehicle operators will heed this admonition is extremely doubtful yet if they could be made to realize that traffic restriction in the spring means better roads throughout the entire summer, selfish motives ought to prompt them to refrain from cutting up the roads any more than absolutely necessary.

SAND FOR ASPHALT PAVEMENTS

During the past few years highway engineers have given considerable attention to specifications of road materials and as the result of the scientific control of the physical properties of the elements entering into pavements, better highways are now being constructed than were produced with the same materials a decade ago. Experience has taught the road builder that the size and shape of stone, the consistency of bituminous materials and the fineness of cement all bear important relationship to the resulting pavements. Indeed, the manner in which a road surface is finished affects the life of the pavement.

Elsewhere in this issue appears an article by Prevost Hubbard, Chemical Engineer of the Asphalt Association, in which it is pointed out that the physical characteristics of the sand entering into sheet asphalt pavpaving mixtures are very important.

"Theory and practice," says Mr. Hubbard, "agree on the desirability of using sand with relatively low percentage of voids when the grains are in intimate contact. Experience has shown that when certain grading requirements are met the percentage of voids may be kept within satisfactory limits without sacrificing other necessary characteristics, such as ability to carry mineral filler. Such requirements are therefore usually included in specifications."

CONVICT LABOR

With the lowering of labor costs some states are abandoning the use of convicts on road work. The Satte of Kentucky has recently announced its intention to discontinue the use of convicts for road work.

During 1919 and 1920, when labor was scarce and high in cost, a number of states pressed convicts into service and for the most part satisfactory results were obtained. New York, California and Nebraska, as well as other commonwealths, have found the employment of convicts profitable. However, with the changing economic situation, it is actually often possible to hire laborers at less than it costs to maintain convicts in road camps. Accordingly, it is probable that the tendency will be to use less convicts on road work.

CARING FOR TOURIST TRAFFIC

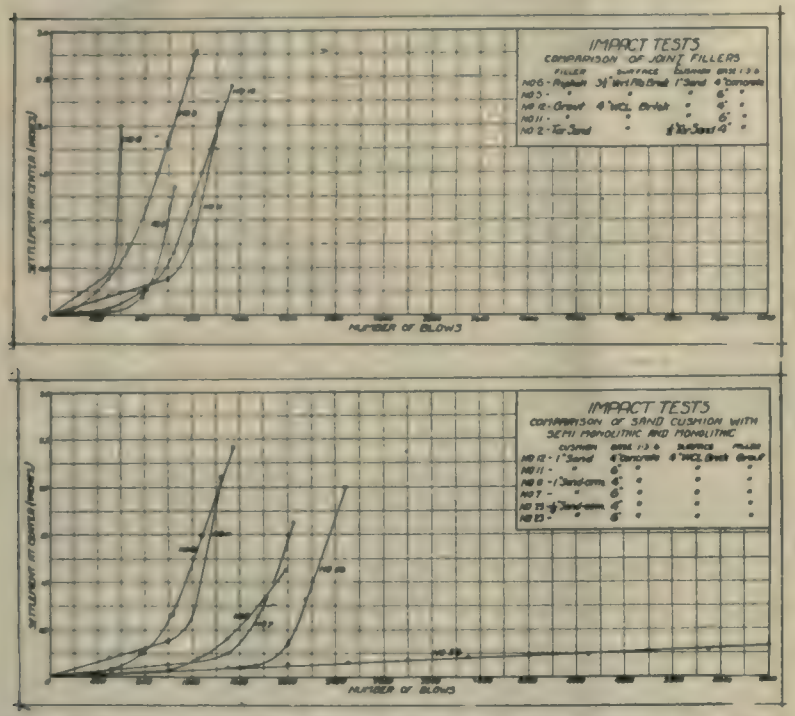
The summer season will soon be in full swing and thousands of people will go forth seeking beautiful scenery, cool woods and shimmering mountain lakes. Behind them, they will leave a golden trail of revenue for the localities they have to visit. This fact was emphasized in a recent statement by Willard M. Bryant, Field Secretary of the Michigan State Good Roads Association. Mr. Bryant stressed the importance of rushing to completion the good roads program as laid out in the state, saying that as soon as the main trunk lines are completed, the association plans to ask the legislature for an appropriation to be used in advertising Michigan as a summer resort country throughout the Middle West and the Mississippi Valley. It is believed that, if this plan were carried out in the right way, the people of the state would receive a yearly revenue of $75,000,000 to $100,000,000 from the resort trade.

Highways which open up vacation playgrounds to the motorist frequently run through sparsely settled territory, devoid of producing farms, and connect towns and villages which have no industries, so that it is difficult to convince the taxpayer of their value. However, the tendency seems to be to construct roads for the tourist even if they serve no other purpose as, for example, the road now being built by the State of Colorado to the summit of Mt. Evans. New York State, too, has set an example for its neighbors with a fine system of roads through the Adirondacks.

HIGHWAY RESEARCHES AND WHAT THE RESULTS INDICATE

(Continued from page 226)

on the proper thickness of concrete slabs for subgrades having bearing values approximately like those in these tests.



VI. IMPACT CURVES FOR BRICK, SAND CUSHION, SEMI-MONOLITHIC AND MONOLITHIC BITUMINOUS JOINT FILLER

We do not propose the following analysis as a rational method of design but simply offer it as an analysis which goes far to aid our judgment in the selection of the proper thickness of concrete surfaces under the stated conditions of traffic. We consider that the maximum impact of motor vehicles is invariably delivered by the rear wheels. An analysis shows that the total weight on the rear wheels of motor trucks of all sizes is practically directly dependent upon the load carried on the truck. This analysis is shown in Curve No. 1 of Fig. VII.

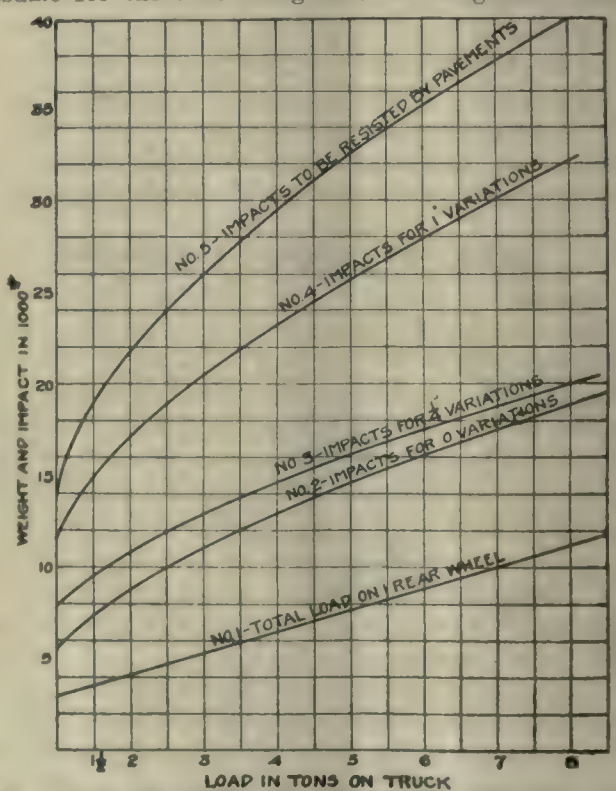
From a mass of some four or five thousand impact tests of motor trucks of different weights and sizes, running at different speeds, we have been able to plot curves shown by Nos. 2, 3 and 4, Fig. VII, indicating what impacts are generally to be expected from motor trucks with known weights on the rear wheels. Curve No. 3 shows the impacts which might be expected for ¼ in. height of fall, which we assume to be the usual condition, and since we wish to make our pavements with a factor of safety of two, we have doubled these impact values, thus giving Curve No. 5, which represents the impact to be resisted with safety by the pavement. In making our impact tests on slabs, we knew definitely the height of fall at the last blow before failure and by means of an autographic device we have been able to obtain a measure of this blow so that we know what blow it corresponds to in terms of a motor truck which is most likely to deliver such a blow. This analysis is presented in Curves 8 and 9. Curve 9 is really an indication of the safe thickness of plain concrete slab to use to withstand motor trucks having a freight load such as indicated.

It must be emphasized again that this analysis does not offer the rational method of design of general application but merely serves to aid our judgment of what the proper thickness of the road might have to be in order successfully to carry traffic of the weight indicated when the subgrade conditions are such as obtained at Arlington Farm. We have obtained a definite measure of these subgrade conditions through an impact test to determine the bearing value of the soil. This test is illustrated in Fig. X.

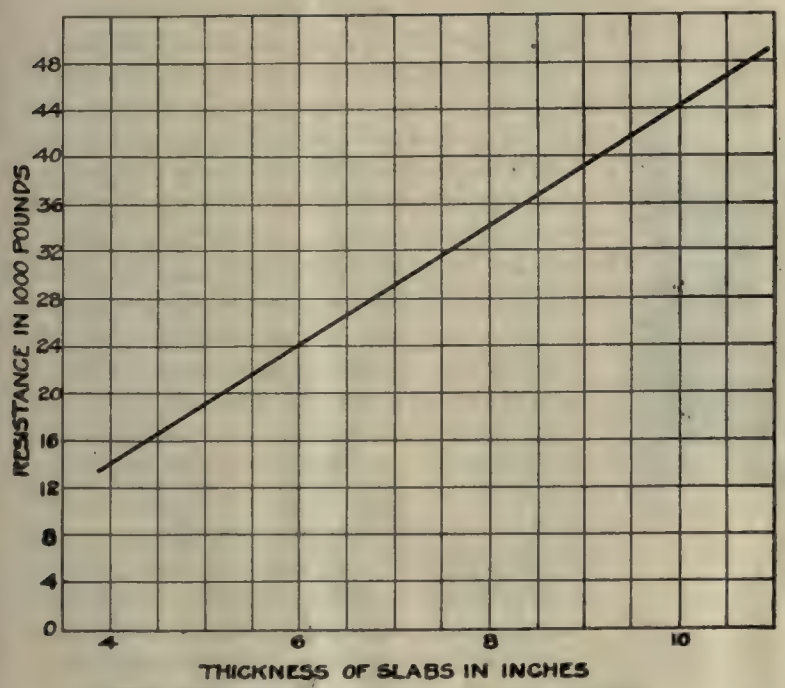
The apparatus consists of a weight of 10 lb. which is allowed to fall from a height of 3 ft. upon a circular plunger also weighing 10 lb. and covering an area of about 15 sq. in. The penetration of this plunger under 50 blows varied from 2 to 4 in., depending upon the variations of the subgrade.

Temperature Stresses in Concrete Pavements

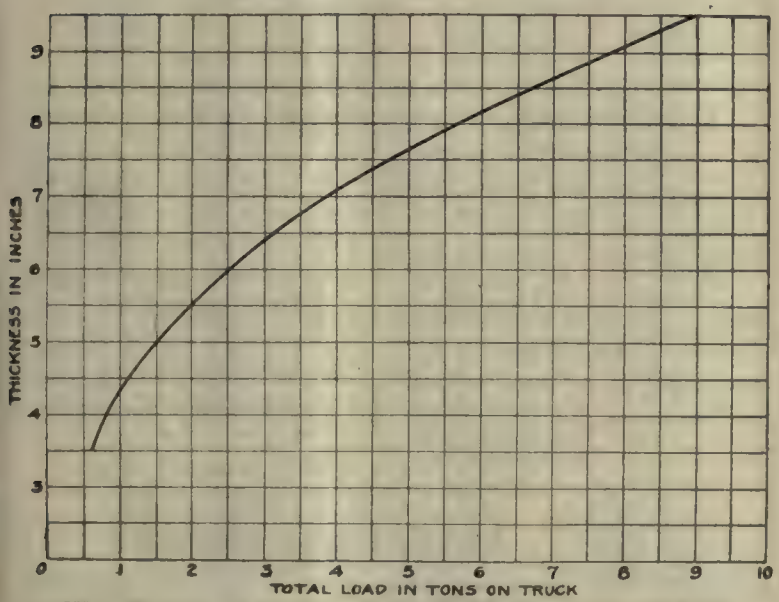
It might be thought without stopping to consider the matter to any great extent, that when concrete is poured upon the subgrade, is finished and hardened to form a concrete pavement, that thereafter there should be offered practically uniform support by the underlying subgrade provided there is no heaving of the subgrade. But, of course, this is far from being the case. Let us assume for the time being that the subgrade remains



VII. LOAD IN TONS ON TRUCK VS. WEIGHT AND IMPACT IN 1000 LBS.



VIII. THICKNESS OF SLAB. RESISTANCE.



IX. TOTAL LOAD IN TONS. THICKNESS IN INCHES.

X. SOIL IMPACT TEST.

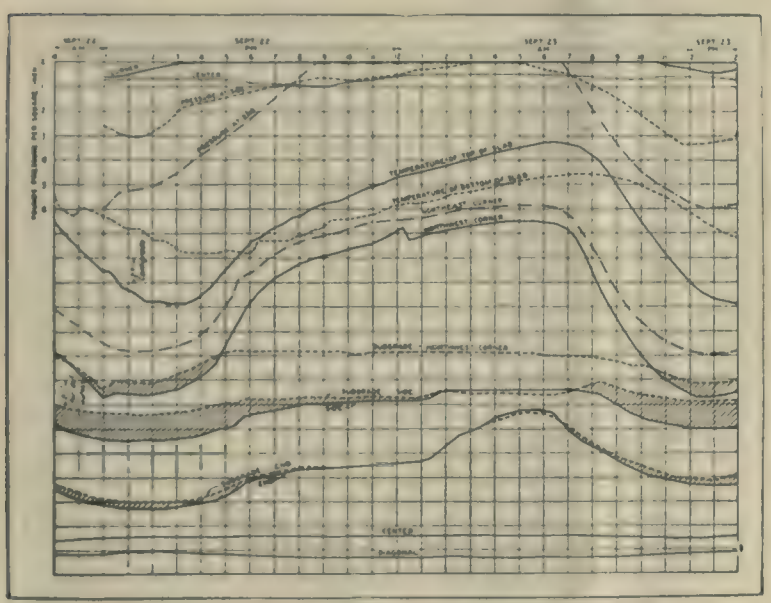
in a uniform condition and does not change its degree of support or its elevation. Even under those conditions the slab does not bear uniformly because it is being continuously warped out of shape by changes in temperature. As the air temperature rises, naturally the top of the slab is heated up more rapidly than the bottom, there is an expansion of the entire top of the slab without corresponding expansion of the bottom of the slab and the result is that there is actual curling down of the edges and corners, making them bear harder against the subgrade than at the center and, in fact, the center may be raised entirely free from the subgrade. On the other hand, at night as the air temperature falls, the top of the slab will be affected first and will be contracted, with the result that there will be curling up of the edges and corners to such an extent that they will be entirely free from the subgrade, the slab then being supported as the center.

In Fig. XI there is shown a view of an experimental slab laid at Arlington for the purpose of determining the extent to which this curling action can take place. It is equipped with wells through which samples of subgrade may be obtained and with metal plugs set in the concrete upon which precise levels are taken. Autographic temperature recording devices, as well as autographic devices for measuring the movement of the slab, are installed.

On Fig. XII there is a typical set of curves showing the temperatures at the top and bottom of the slab at different hours during the day, and showing also the vertical movement of the corners and sides of the slab. The curves at the top of Fig. XII show pressure readings taken between the slab and the subgrade by means of a special device for reading soil pressures. Note that these pressures are variable. If they had been constant the slab would have been receiving constant support from the subgrade, but when the edges and corners of the slab are curled down, naturally the pressure readings under the corners and edges are greatly increased.

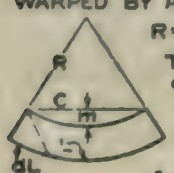
Let us see what significance this warping action might have in connection with concrete pavement design. Let us assume, and this might very readily be the case, that there is a difference in temperature between the top and bottom of the slab equal to 36° F.; let the pavement be eighteen feet in width and eight inches in thickness, and let the temperature at the top of the slab be lower than that at the bottom, the sides and corners thus being elevated from the subgrade.

XI. SLAB FOR MAKING TEST WARPING MEASUREMENTS.



XII. CURVE OF WARPING.

CASE I - STRESS PRODUCED BY DEFLECTING THE END OF AN 18'x1'x8" CONCRETE BEAM TO ITS LOWEST POSITION AFTER IT HAD BEEN WARPED BY A TEMPERATURE CHANGE OF 36° F.



$R = \frac{c^2}{8m}$; $R = \frac{d \times L}{dL}$; $C = L$ $dL = T \times c \times L$

T = Temp. change, degrees F. = 36

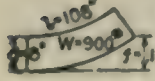
C = Coef. of change per degree F. = .0000055

By substitution, - $m = \frac{Tcl^2}{8d} = \frac{36 \times .0000055 \times 216 \times 216}{8 \times 8} =$ .144 of an inch.

Assuming the beam to be supported at the center each half becomes a cantilever of length = 108 ins.

Deflection due to weight of beam:- $f = \frac{Wl^3}{8EI} =$

$\frac{900 \times 108 \times 108 \times 108 \times 12}{8 \times 3000000 \times 8 \times 8 \times 8 \times 12}$ $f = .094$ of an inch.



The stress produced by the weight of the beam:-

$\frac{Wl}{2} = \frac{sI}{c}$; $S = \frac{Wlc}{2I} = \frac{900 \times 108 \times 4 \times 12}{2 \times 12 \times 8 \times 8 \times 8} = 380$ #per sq in

The load required to deflect the end the remaining .05" is found from:-

$P = \frac{3fEI}{l^3} = \frac{3 \times .05 \times 3000000 \times 8 \times 8 \times 8}{108 \times 108 \times 108}$ P = 183 lbs.

The stress produced by the load is found from

$S = \frac{Plc}{I} = \frac{183 \times 108 \times 4 \times 12}{12 \times 8 \times 8 \times 8}$ S = 154 lbs. per sq. in.

Total stress will be 380 + 154 = 534 lbs. per sq. inch.

XIII. CALCULATION OF STRESS DUE TO WARPING SLAB.

As shown in Fig. XIII with a difference in temperature of 36°, there is the possibility of a warping up of the edges equal to 0.144 in. but owing to the weight of the slab these ends will be bent down 0.094 in. with a resulting tensile stress of 380 lb. per square inch tension in the top of the slab at the center. The edges of the slab would still be raised 0.05 in. off the subgrade, and if two vehicles passed one another there would be a possibility of bending the slab down into contact with the subgrade. If loads were applied at the extreme edges of the pavement, a running load of 183 lb. per square inch would be created in the center of the pavement, or a total stress of 564 lb. per square inch. When it is considered that 600 lb. per square inch is the modulus of rupture of concrete, it will be seen that under extreme conditions of warping, stresses are produced that might in some cases account for longitudinal cracking, omitting entirely from consideration the character of the subgrade. If the slab, on the other hand is only 9 ft. in width, the warping produced under the same conditions would be only 0.036 in., the weight of the slab then producing a stress of 95 lb. per square inch, and the total stress at the center when the slab is bent down entirely into contact with the subgrade then being 465 lb. per square inch, requiring, however, a running load of 878 lb. placed at the extreme edges of a 9-ft. pavement to produce this result. So it would seem that there is practically no possibility of a 9-ft. slab cracking longitudinally owing to warping effects, whereas there is a strong possibility of a longitudinal crack forming in an 18-ft. slab.

(To be continued)

THE OSTERMAN MEMORIAL

The effective work which the late H. C. Osterman accomplished for the Lincoln Highway during the years he was vice president and field secretary of the Lincoln Highway Association is to be most appropriately memorialized. The association, through its board of directors, has approved the design for a memorial seat to be erected at a beautiful spot along the ideal section of the Lincoln Highway in western Indiana. The seat will be set back slightly from the road where it may ultimately become the nucleus for an ideal camp site planned by the association.

Union County, New Jersey, recently adopted a pavement program involving the estimated expenditure of $753,000 for new roads and resurfacing.

FEDERAL AID BILL REPORTED IN HOUSE

The House Committee on Roads has reported out the Dunn bill appropriating $65,000,000 for federal aid during the next fiscal year and $75,000,000 for the year ending June 30, 1924. The committee deemed it advisable to provide for a two-year program only in the hope that the financial situation might improve and that it might be possible later to return to the appropriation of $100,000,000 annually. The bill also carries $6,500,000 for forest roads and trails during the second fiscal year.

The bill requires that the states begin work on the projects within one year after the money is allotted and fixes the maximum federal aid at $12,500 per mile during the next fiscal year, instead of $20,000 per mile as at present, and $10,000 per mile during the second year. Provision is also made to extend for five years the time in which Texas, Arkansas, and some other states may change their constitutions to comply with the Federal Aid Act.

Other features of the bill permit the federal government to participate in underpass as well as overhead construction in railroad grade crossing eliminations, and money allotted to a definite project to be transferred to another on the abandonment of the original project.

NEW MACHINE FOR PLACING CONCRETE

A new machine for the placing of concrete has been developed by the Austin Machinery Corporation, Chicago, Ill. This machine is called the "Distributor" and by its use the boom and bucket are eliminated.

The "distributor" is an entirely separate machine—a new unit in a modern road building outfit. It runs on the forms just as the tamper does, and is operated by a small gasoline engine, with traction both forward and backward. Direct from the discharge spout of the mixer, it receives the entire batch in a troughlike receptacle that extends the full length of the machine, which means the full width of the road. This trough is kept in a constant state of oscillation all the while that the machine is being run back on the forms, and right up to the moment when the concrete is dumped. In effect it continues and prolongs the mixing process, and with its aid even the driest mix can be delivered on the ground in its most plastic form.

Arriving at the spot where the concrete is to be dumped, all the operator has to do is to throw into gear a clutch which turns the trough upside down. The result is a ridge of concrete spread over the entire space from curb to curb. Then, as the machine starts back to the mixer for its next load, its strike-off board, adjusted to the proper crown, spreads the concrete and smooths it down to the desired level. The distributor thus does mechanically what heretofore has had to be done by several men with shovels and hoes. Moreover, it leaves ready for the tamper a surface that is far more uniform than can ordinarily be secured by hand labor.

HIGHWAY COSTS IN INDIANA

C. C. Gray, State Highway Engineer of Indiana, has stated that the forty miles of road placed under contract several weeks ago at approximately $1,000,000 will be built at about $8,500 a mile cheaper than was possible last year. Concrete pavement at that time cost about $36,500 a mile. The contracts recently awarded for concrete roads show an average cost of about $27,500 a mile. Mr. Gray points out that this saving will permit the commissioners to build seven miles more road for the same amount of money as compared with last year.

GOOD ROADS IN DELAWARE

Delaware is planning to build 60 mi. of road this year, which will bring the total mileage of paved roads up to 270 mi. The State Highway Department has compiled figures showing that Senator duPont has spent more than $3,000,000 for the boulevard which he gave to the state. This boulevard is over 100 mi. in length and most of it is completed and already in use, but the expense of completing and beautifying the road will bring the total cost to $3,500,000.

COUNTY TO PROTECT ITS PAVED ROADS

With a 1922 program calling for the expenditure of $300,000 on improved highways, the county commissioners of Erie County, Pennsylvania, have turned their attention to the matter of protecting the paved roads from destruction. To this end they have decided to purchase scales for weighing all trucks using the county highways. The scales will be set up in Erie, and state, county and city authorities will have charge of apprehending operators of overloaded trucks.

The State of Utah recently awarded road construction contracts totaling about $950,000. One of the contracts was for the longest stretch of hard surface pavement yet to be let in one job in the state, about 15.5 mi.

The City of Wilmington, Del., recently sold $517,000 of 4½ paving bonds to Farson, Son & Co. and J. S. Bache & Co. at $527,783.

Thirteen Bridges in Delaware County, Pennsylvania, have been declared unsafe and County Judges Johnson and Bromall have ordered ten of them rebuilt at a cost of approximately $600,000.

Welland County, Ontario, will spend $460,000 on road construction and $100,000 on maintenance this year.

Cocke County, Tennessee, has authorized the issuance of $300,000 of road bonds. The state and the Federal Government will each furnish a like amount, making a total of $900,000 available for road work in that county.

MEETINGS

Calendar of Coming Meetings

May 12—National Highway Traffic Association—Annual meeting, Automobile Club of America, New York City. Secretary, Elmer Thompson, 247 West 54th St., New York City.

June 4-6—American Association of Engineers—Annual convention, Salt Lake City, Utah. Secretary, C. E. Drayer, Chicago, Ill.

June 13-16—Canadian Good Roads Association—Ninth annual convention, Victoria, B. C. Secretary-treasurer, George A. McNamee, Birks Bldg., Montreal, Canada.

June 26-July 1—American Society for Testing Materials—Twenty-fifth annual meeting, Atlantic City, N. J. Secretary, C. L. Warwick, Engineers' Club Bldg., Philadelphia, Pa.

Oct. 9-13—American Society for Municipal Improvements—Annual convention, Cleveland, O. Secretary, Charles Carroll Brown, St. Petersburg, Fla.

COLORADO TO BUILD ROAD TO SUMMIT OF MOUNT EVANS

The Colorado State Highway Department has advertised for bids for the construction of the first 4.5 mi. of highway to the top of Mt. Evans. The Commissioner of Highway District No. 1, in which Mt. Evans is located, has definitely stated that he will specify in the 1923 budget that sufficient funds be appropriated to complete the road to the summit. In view of this statement, Secretary of Agriculture Wallace has announced that further action in the matter of granting a permit to private parties for the building of a toll road up Mt. Evans will be suspended. The proposition to build a toll road, which was considered by Secretary Wallace on the ground that the people of Colorado would not feel justified in spending public funds for such a project, met with considerable opposition in the state and was called an attempt to commercialize the scenery of Colorado.

HIGHWAY ENGINEER AWARDED DAMAGES

Dudley P. Babcock, of Albany, N. Y., has secured an award of $10,000 from the Court of Claims for injuries sustained while in the employ of the State Highway Department on the preliminary survey of the famous Storm King Highway. He had previously carried his claim through every court of record in the state and had obtained an enabling act from the legislature to prosecute.

In making the preliminary survey for the road around the face of Storm King Mountain, it was necessary to lower the engineers down the precipitous mountainside on ropes. The accident to Mr. Babcock occurred when the rope on which he was suspended broke and caused him to fall more than one hundred feet.

HEARING OF ELIMINATION OF GRADE CROSSINGS IN NEVADA

A hearing before the Public Service Commission will be held April 25 at Carson City, Nevada, to fix the rate of participation by the railroad companies in the expense of eliminating grade crossings on the highways of the state. The Public Service Commission law of the state provides an avenue through which the railroads can be requested to assist in such work and all companies operating in the state have been summoned to appear at the hearing. In some states, such participation is fixed by general agreement and it is hoped that Nevada may secure some such fixed ratio.

KENTUCKY ABANDONS USE OF CONVICTS

The General Assembly of Kentucky has enacted a law which puts an end to the use of convict labor on roadv work except for the purpose of quarrying stone or other material used by the state in the construction of roads and bridges and permits it then only in case the quarry is enclosed by walls or stockade. The proponents of the bill claimed that convict labor has been a failure. They pointed out that the cost of policing the work was high, that there were numerous escapes in spite of the money spent for policing, and that it had been pretty thoroughly demonstrated that a fair day's work was not given by a prisoner.

The West Virginia Highway Commission recently awarded contracts for the construction of roads to cost approximately $2,000,000 and work is expected to begin as soon as the contracts are signed. The 28 contracts cover projects in 21 counties, with a total mileage of 65 mi.

PERSONAL MENTION

E. R. Thomas, City Engineer of Port Arthur, Texas, has resigned.

George H. Rowe, Assistant Engineer of the Board of Public Utilities of Los Angeles, Cal., has been appointed assistant engineer with the California State Highway Commission.

F. H. Rood, formerly Assistant Engineer of Tests of the Pittsburgh Testing Laboratory, Pittsburgh, Pa., has resigned to accept a position as Research Engineer, Office of Public Roads, with headquarters at Harrisburg, Pa. He has been assigned to the Advisory Board on Highway Research of the National Research Council under the direction of H. S. Mattimore, Chairman of the Committee on Character and Use of Road Materials.

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

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Volume LXII April 26, 1922 Number 17

TABLE OF CONTENTS

*Highway Researches and What the Results Indicate. By A. T. Goldbeck 233

Efficient Methods of Providing for Traffic During Construction. By A. R. Hirst 238

*Cost of Highway Construction 242

New Motor Truck Regulations in New York . . . 243

Cement Manufacturers on Trial 243

Maintenance of Gravel Roads. By A. H. Cunningham 244

Bates Experimental Road Tests 245

Types of Construction on Lincoln Highway in 1921 245

Minnesota to Spend $30,000,000 245

Would Have State Cement Plant 245

Brick Varieties Reduced to Seven 246

Highway Policy of Iowa for 1922 246

Preference for Ex-Service Men 246

EDITORIAL:

Highway Research 241

MEETINGS:

Calendar 246

Dixie Highway Association 246

PERSONAL MENTION 246

*Illustrated Article

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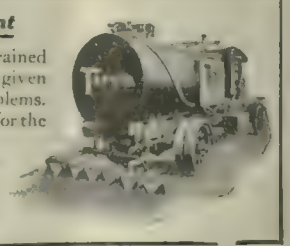

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GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

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THE HIGHWAY CONTRACTOR AND ROAD BUILDER

Vol. LXII. NEW YORK, N. Y., APRIL 26, 1922 No. 17

Highway Researches and What the Results Indicate*

By A. T. GOLDBECK†

(Continued from last issue)

We must not forget the possibility of slabs being warped owing to moisture. It is a well known fact that concrete expands and shrinks upon being wetted and dried. Experiments made at the Bureau of Public Roads several years ago showed that from a wet condition to a condition of extreme dryness, obtained after three months' hardening in a dry atmosphere, concrete will shrink from .05 to .06 in. per inch of length, approximately the same amount of shrinkage that would be expected from a fall in temperature of 100° F. Concrete laid on a subgrade, however, will not be subjected to this extreme range because, although the surface is subjected to rapid drying, the concrete is in contact with a moist subgrade. There is certainly a possibility, however, of a difference in expansion at the top and bottom of the slab, since the bottom is apt to be subjected to more uniform moisture conditions owing to its contact with the subgrade. The top, on the other hand, is subjected to the extreme ranges of wetness and dryness.

Referring to Fig XV, let it be assumed that the moisture coefficient of expansion is 0.00025, a figure much less than the extreme expansion possible. If in an 18-ft. pavement, 8 in. thick, such a slab will be deflected 0.182 in., the sides will be raised this amount. The dead load stress due to the weight of the slab alone will bend the ends down 0.094 in. and will produce a stress of 380 lb. per square inch, and if the sides of the slab were bent down by traffic there would be an additional stress of 271 lb. per square inch, or a total of 651 lb. per square inch. Again, it is seen that there is the possibility by stress tending to produce longitudinal cracking owing to moisture effects alone. Similarly, there is possibility of high stress owing to the warping up of the corners of the slab due both to moisture and to temperature. This is illustrated in Fig. XVI.

Let me emphasize, however, that these are theoretical considerations which may or may not obtain in the pavement. There are several phenomena which tend to alleviate the severe stress conditions indicated by the theoretical calculations. Thus, the subgrade support is much more widely distributed than assumed in these calculations. Again, the phenomenon of "flow" of concrete, which has been investigated in the Bureau of Public Roads and elsewhere, would permit the gradual yielding of the concrete back into contact with the subgrade without the production of as high a stress as indicated. Nevertheless, the possibility of high stresses exists due to warping and should be very carefully considered in the design of pavements.

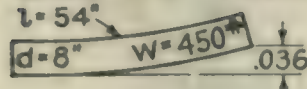
Investigations of the Subgrade

Let us next look into the influence of the subgrade on the design of pavements and consider some of the investigations that are being carried on to determine how to take this influence into account. We are all well aware that there is a very great variety of soils throughout the country in which the physical characteristics and chemical composition vary through a wide range. The chemical composition, of course, must vary as widely as that of the rocks from whose disintegration the soil has resulted. The physical characteristics are evident in a rough way even with the most casual observation. For our purpose we consider that soils are made up of particles of various sizes extending all the way from gravel down through sand, silt and clay, even to particles known as ultra clay, which are so very fine that when stirred up in water they will never settle to the bottom. Imagine, if you will, a soil made up of these extremely finely divided particles. Such a soil when saturated with water would have no inherent stability and would support practically no load at all, but as more and more coarse particles are mixed with such a material it can readily be imagined that such particles would furnish a skeleton structure through their arching

*Paper presented at annual convention of the American Road Builders' Association.

†Chief, Division of Tests, U. S. Bureau of Public Roads, Washington, D. C.

CASE I-a. BEAM 9'×1'×8".



Deflection due to weight of beam $= f = \frac{Wl^3}{8EI} = \frac{450 \times 54 \times 54 \times 54 \times 12}{8 \times 3000000 \times 8 \times 8 \times 8 \times 12}$

$f = .0058$ of an inch.

Stress produced by weight of beam,-

$S = \frac{Wlc}{2I} = \frac{450 \times 54 \times 4 \times 12}{2 \times 8 \times 8 \times 8 \times 12}$ $S = 95$ lbs. per sq. in.

The load required to cause the remaining deflection of .03" $P = \frac{3fEI}{l^3} = \frac{3 \times .03 \times 3000000 \times 12 \times 8 \times 8 \times 8}{54 \times 54 \times 54 \times 12}$

$P = 878$ lbs.

The stress produced by a load of 878 lbs.

$S = \frac{Plc}{I} = \frac{878 \times 54 \times 4 \times 12}{8 \times 8 \times 8 \times 12}$

$S = 370$ lbs. per sq. in.

Total stress is 95 + 370 = 465 lbs. per sq. in.

XIV. CALCULATION OF STRESS DUE TO WARPING OF 9' x 8" SLAB.

CASE II - STRESS PRODUCED BY DEFLECTING THE CORNER OF AN 8 IN. THICK CONCRETE SLAB TO ITS LOWEST POSITION, AFTER THE END HAS WARPED UPWARD .055 OF AN INCH.

Initial stress due to weight of concrete:-

$S = \frac{WL^2}{d^2} = \frac{100 \times 60 \times 60}{144 \times 8 \times 8} = 39$ lbs. per sq. in.

$R = \frac{C^2}{8m}$, $\frac{R}{L} = \frac{d}{dL}$; $R = \frac{d \times L}{dL}$; $C = L$.

By substitution:- $\frac{d \times L}{dL} = \frac{L^2}{8m}$ $\therefore dL =$

$\frac{d \times L \times 8 \times m}{L^2} = \frac{8dm}{L} = \frac{8 \times 8 \times .01375}{60} = .0147$."

Stress = unit deformation times the modulus of elasticity:- $\therefore S = \frac{dL}{60} \times E =$

$\frac{.0147}{60} \times 3000000 = 735$ lbs. per sq. in.

Total stress is 735 + 39 = 774 lbs. per sq. inch.

XV. CALCULATION OF STRESS DUE TO MOISTURE CHANGES.

CASE III - STRESS PRODUCED BY DEFLECTING THE END OF AN 18' x 1' x 8" CONCRETE BEAM TO ITS ORIGINAL SHAPE AFTER IT HAD BEEN WARPED BECAUSE OF DIFFERENCE OF MOISTURE CONTENT BETWEEN TOP AND BOTTOM.

$R = \frac{C^2}{8m}$, $R = \frac{d \times L}{dL}$; $C = L$.

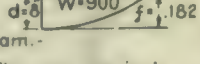
$dL = c'L$. c' = Unit change in length between top and bottom fibres = .00025.

By substitution: $m = \frac{c' \times L^2}{8d} = \frac{.00025 \times 216 \times 216}{8 \times 8} = .182$ inch.

Assuming the beam to be supported at the center each half becomes a cantilever of length = 108 ins. Deflection due to weight of beam:

$f = \frac{Wl^3}{8EI} = \frac{900 \times 108 \times 108 \times 108 \times 12}{8 \times 3000000 \times 8 \times 8 \times 8 \times 12}$

$f = .094$ of an inch



Stress produced by weight of beam.-

$\frac{Wl}{2} \cdot \frac{SI}{C}$; $S = \frac{Wlc}{2I}$ $S = 380$ lbs. per sq inch

The remaining deflection of .088 of an inch will be accompanied by a stress of 271 lbs per sq. in. and was found from the formula:-

$S = \frac{3fEd}{2l^2}$

Total stress will be 380 + 271 = .651 lbs. per square inch.

XVI. CALCULATION OF STRESS DUE TO WARPING OF CORNERS.

over and intimate contact and such a soil would then have some stability even when wet.

In the laboratory we have been analyzing by means of physical tests a number of samples of soil which have been taken from road failures as well as from road successes. Briefly, these tests are as follows:

(1) **Mechanical Grading.** The soil is analyzed to determine the range of sizes of its various particles. This is done by first boiling a 25-gram sample of the soil in water for a few minutes, allowing it to stand for 24 hours, thoroughly breaking it up and agitating it, allowing the liquid to settle for 8 minutes, then pouring off the supernatant liquid. Washing and settling are repeated until the supernatant liquid is clear. The sample remaining after washing contains silt and particles larger than this. The dried sample is then passed through the Nos. 200, 100, 50, and 20 mesh sieves, that passing the No. 200 being recorded as silt, and that above as sand. The clay and ultra clay are contained in the water used for washing the sample. This is thoroughly agitated and the sample is placed in a centrifuge and whirled for half an hour at a speed of fifteen hundred revolutions per minute, thus preciptating the clay but not the ultra clay, which remains suspended in the liquid. The ultra clay is recovered by pouring off this liquid and evaporating it to dryness. Thus there has been determined the percentages of clay, ultra clay, silt, and the various percentages of sand particles.

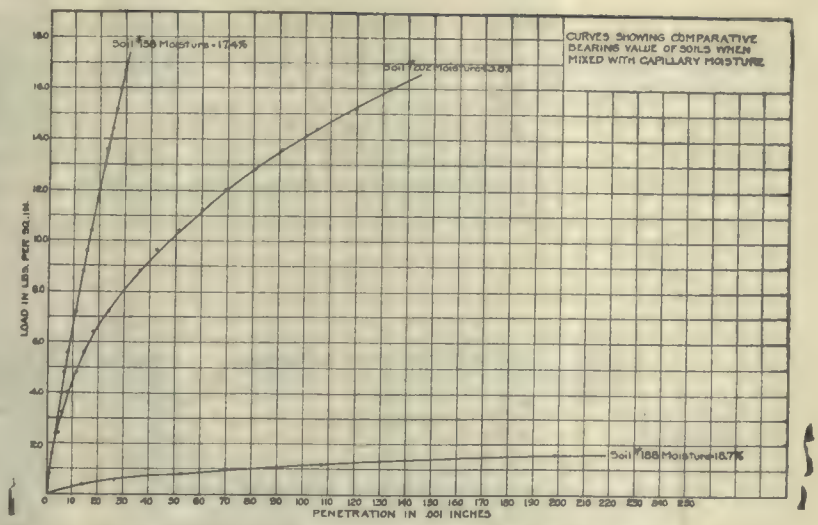
(2.) **Water-weight**—Tests are also made for the so-called water holding capacity of soils by immersing a sample of the soil and obtaining the weight of water taken up by the sample. This varies tremendously, depending very largely on the grading analysis of the soil.

(3.) **Moisture Equivalent.** The moisture equivalent of a soil as determined in our laboratory is the percentage of moisture retained by the soil when subjected to a centrifugal force equal to about 750 times the force of gravity for a period of one hour. In this test the sample is allowed to take up moisture by capillarity and is placed in a perforated container so that when whirled in the centrifuge the excess water will be thrown away from the sample. After centrifuging for one hour, the sample is again weighed and the weight of water remaining when converted into percentage is the moisture equivalent. This is a very important test as the moisture equivalent seems to be a very good indication of the bearing value of a soil and is likewise a good indication of the difficulty of draining it.

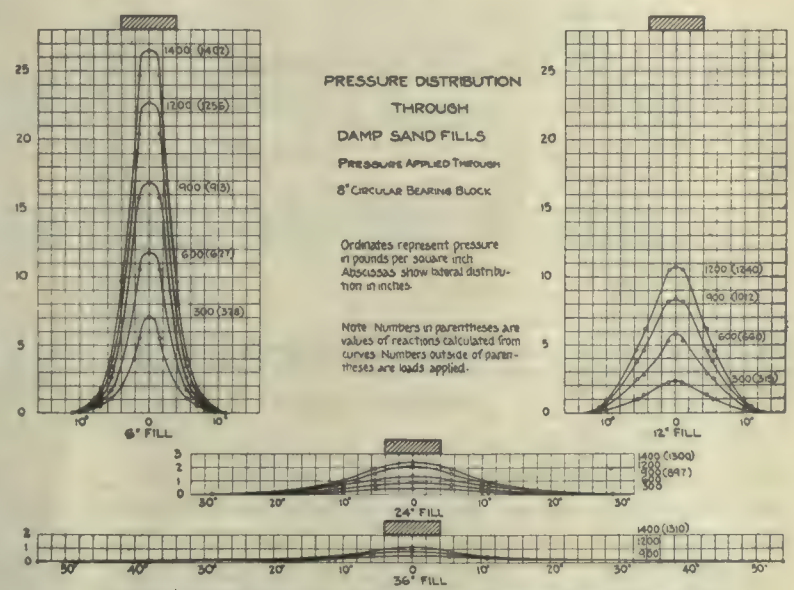
(4.) **Vertical Capillarity.** Water will climb vertically through soils in much the same way that oil is lifted through a lamp-wick, by the force of capillarity, and some oils have the power of drawing water from quite a considerable depth. The test for rate of capillarity is made by noting the time required for water to climb through a sample of soil held in a glass tube, the height of the sample being twenty centimeters. The capillary action of soils is exceedingly important in connection with their drainage. Some of the finely divided soils are capable of high lifts, while some of the granular or sandy soils have very little power of vertical capillarity.

(5.) **Volumetric Change.** This is a test to determine how much shrinkage takes place in the soil from its saturated to its dry condition. It will readily be understood that this is a most important property of soils, for if the subgrade dries out unequally and therefore shrinks unequally, as it does in a great many cases, unequal support is offered to the road. There are instances in which, owing to the subgrade shrinking at the the sides of the road, there has been actual separation of an inch or more between the road surface and the underlying subgrade. And soils such as these cannot be depended upon to offer adequate support even when they are dry.

(6.) **Comparative Bearing Value.** The most important property of soils is their bearing value or their ability to support loads without much yielding. When we consider that the wheel loads on some of our big motor trucks may be 10,000 and more, we can readily see why it is important that soils must be capable of supporting high loads without yielding. In the laboratory this property is determined by preparing samples of soil with various percentages of water, subjecting them to definite compaction by means of pressure and then testing them in a special machine in which a plunger having 1 sq. in. of area is loaded by a gradually increasing load, and simultaneous load and penetration readings are taken during the test. For comparative purposes the bearing value of the soil is taken as that load in pounds per square inch required to produce a penetration of 0.10 inch.



XVII. BEARING VALUE OF 3 TYPICAL SOILS.



XVIII. CURVE OF PRESSURE DISTRIBUTION IN SAND.

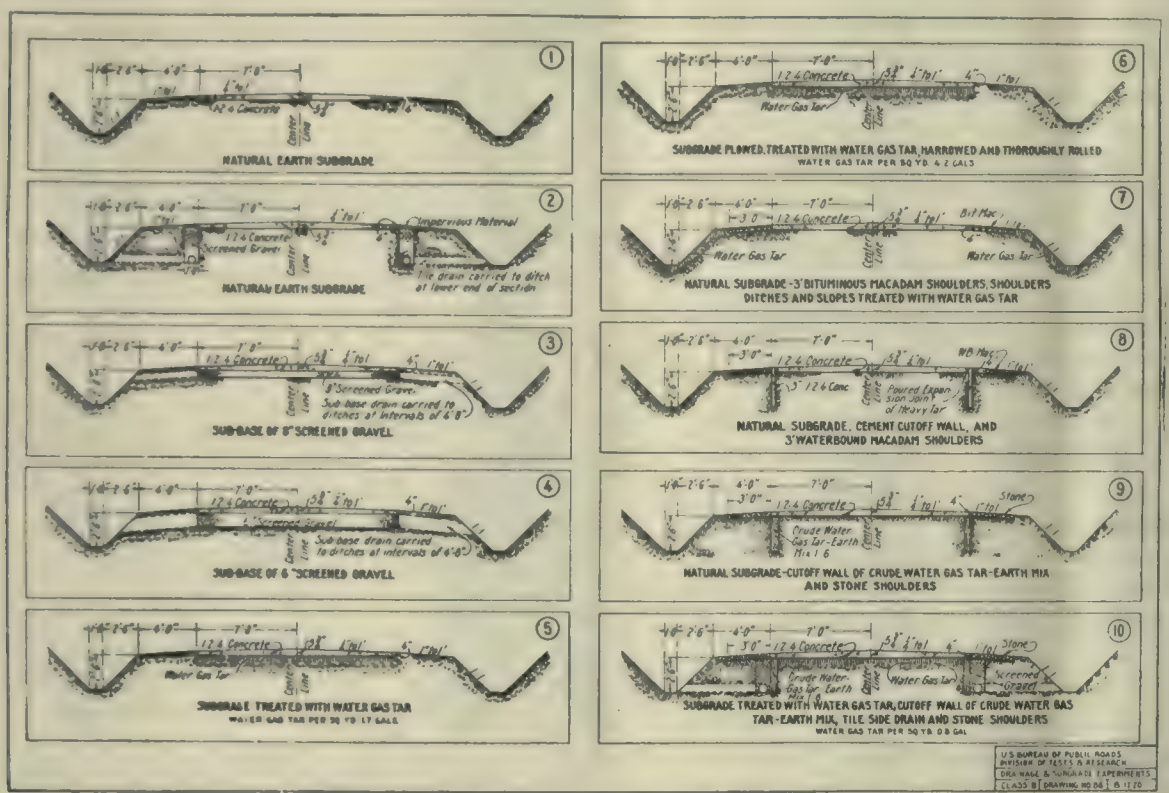
(7.) **Adsorption Test.** It is believed that the extremely finely divided particles which are known as ultra clay have considerable to do with giving the soils their plastic properties, and it appears that ultra clay from various types of soils, varys widely in its characteristics. It is no doubt true that even these extremely finely divided particles, so fine that they will remain indefinitely suspended in water, have a wide range of size in just the same way that sand is composed of widely varying sizes, and this may account for the different properties of colloidal or ultra clay. The so-called adsorption test is in some degree a measure of these different properties of ultra clay. Finly divided particles have the ability to decolorize dye solutions, some samples very much more than others, and the adsorption test is made by determining the amount of dye which can be decolorized by allowing it to filter through a given sample. That sample which has the highest adsorption is likely to render the soil most plastic.

These laboratory tests have been made on a number of samples, but we are not yet prepared to say definitely what range of characteristics of soils corresponds with their behavior in the field. That there is an extremely wide range is well illustrated in Fig. XVII which shows the comparative bearing value of three typical soils. Note the extremely wide range of bearing value of these soils, depending upon their physical characteristics. Note that although one soil has practically no bearing value when it is saturated, the best soil has quite a high bearing value. Soil such as the one indicated by the lower curve would certainly give

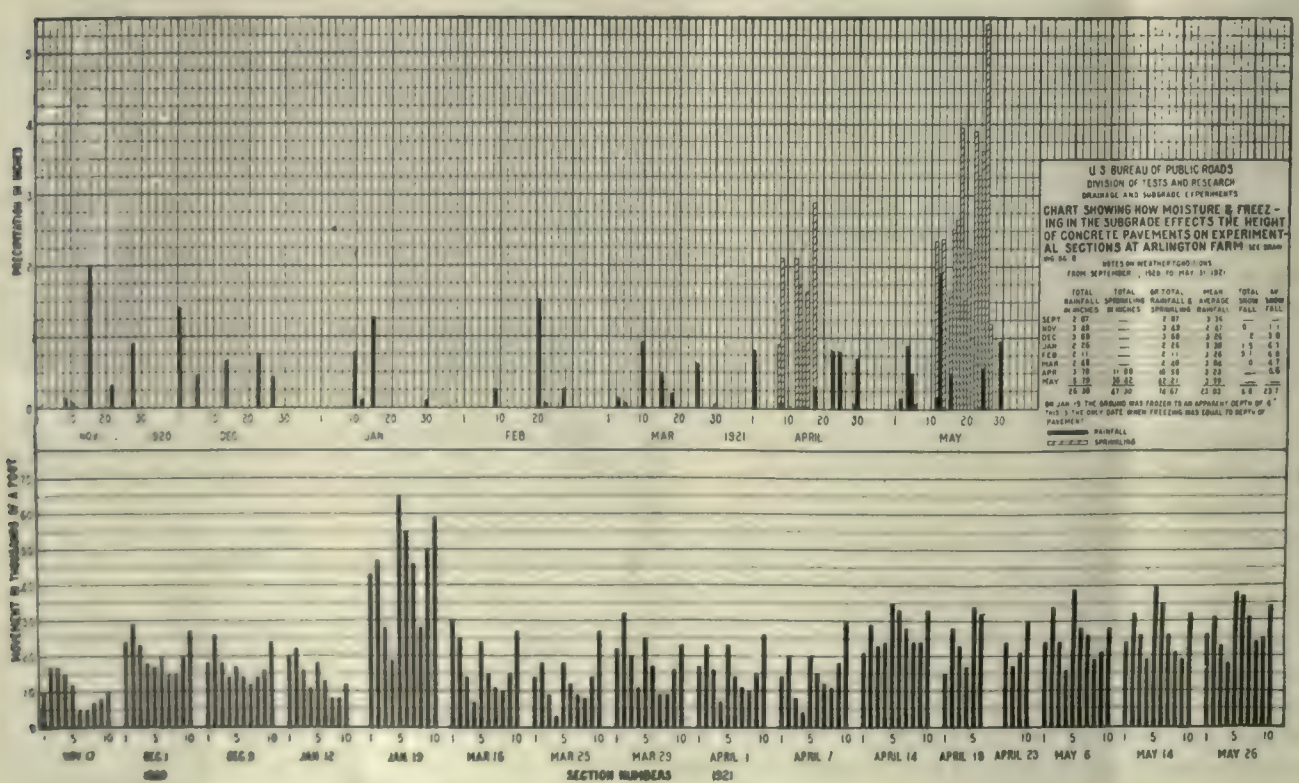
trouble in the subgrade of a road if it became saturated with water, whereas the topmost soil would no doubt give very good results.

In order properly to understand how the bearing value of the subgrade might influence the design of a non-rigid surface, such as gravel and bituminous macadam, it will be necessary to know something of the manner in which pressures are distributed through such surfaces to the subgrade.

The curves given in Fig. XVIII show how pressures would be distributed directly on the subgrade under the wheel of a heavy truck. These particular tests were made by measuring the pressures under layers of sand from 6 in. up to 5 ft. in thickness, the two

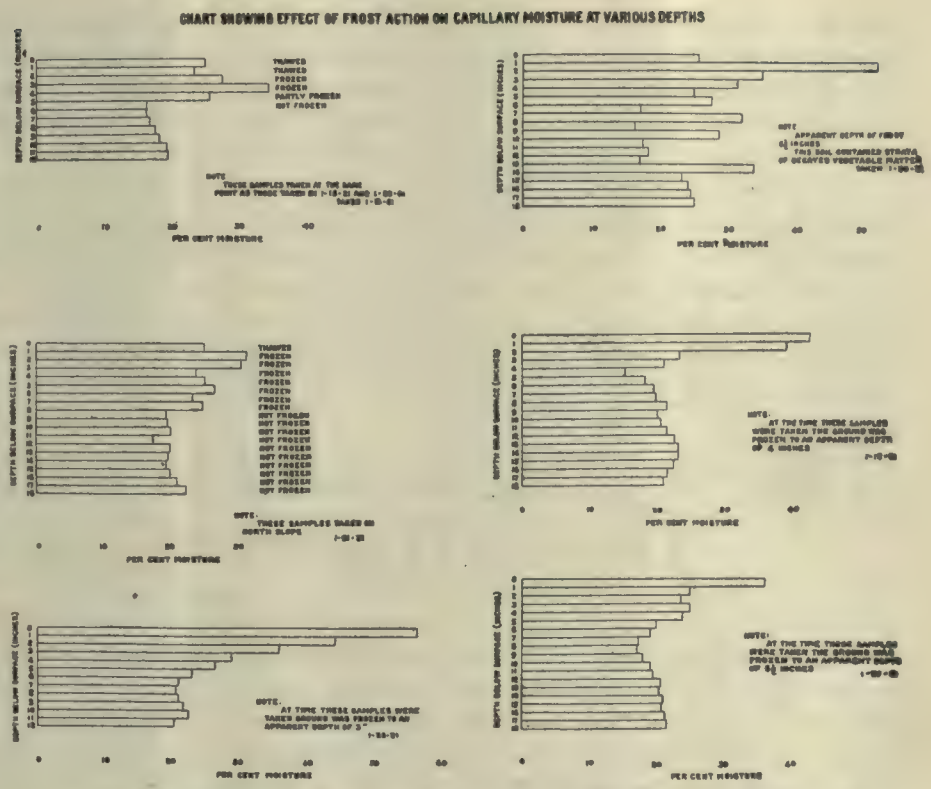


XIX. CROSS SECTION OF DRAINAGE EXPERIMENTS.



XX. DIFFERENCE IN ELEVATION OF THIN SECTIONS.

curves shown being those for the 24-in. and 12-in. layers. The point to be observed in these curves is the fact that when the layer of sand is only 12 in. thick as compared with 24 in. thick, there is a much higher intensity of pressure under the load. We found that when the layer of sand was 5 ft. thick the pressures were widely distributed and were of very low intensity. The lesson to be learned from this is, of course, that the thinner the road surface the higher will be the intensity of pressure on the subgrade, and if the subgrade is soft it becomes very evident why we must have a thick road surface in order properly to distribute the pressure and at the same time reduce the intensity of pressure so that it will be less than the bearing value of the subgrade material. Subgrade material of high supporting value, on the other hand, will permit of the use of a thinner wearing surface because a higher intensity of pressure will be permitted on the subgrade.



XXI. EFFECT OF FROST IN DRAWING WATER TO SURFACE.

Drainage Investigations

It has been mentioned that the water content of the soil greatly influences the bearing value, and it is highly important, therefore, that every possible precaution be taken to reduce the percentage of water in the subgrade to a minimum. A series of tests has been under way at Arlington for several years in which ten different drainage experiments have been made. The details of these experiments are shown in Fig. XIX.

Careful level readings were taken on the concrete slabs in the ten sections indicated in Fig. XIX. The variations in level of these slabs are shown in Fig. XX. It will be necessary to study these in detail in order to see the various effects, and it can merely be pointed out here that there is considerable difference in the movements of the slabs depending upon the drainage of the subgrade.

Apparently Section No. 4, having a sub-base of screened gravel, was as little affected as any of the sections. One very interesting phenomenon brought out by these tests is illustrated in Fig. XXI. Without going into detail it is very evident that freezing of the top layers of soil has an effect in increasing the moisture content of these layers and in decreasing the moisture content in the layers immediately below the frozen portion.

Evidently freezing has the effect of withdrawing moisture from the underlying layers and concentrating it in the frozen layers. This possibly accounts for the extremely high moisture content under road surfaces in the spring of the year. This series of tests is not completed yet and will be carried on further in the field, and it is hoped that finally there will be evolved efficient methods of drainage of different types of soils under various conditions of topography. It is needless for me to point out that there are still innumerable problems to be solved, many problems other than those dealing merely with the structural design for we have just begun to touch the field of road economics.

One very important research which we are now undertaking deals with the study of the elimination of the causes of shoving and creeping of bituminous pavements. This is being undertaken in cooperation with The Asphalt Association by procuring samples of asphalt pavements which have shoved under traffic. These samples are now being sawed into the proper shape and will soon be subjected to laboratory investigations. In addition to this, a field test is being constructed in which a motor truck will be run around a circular track composed of a number of different types of asphalt sections and the behavior of these sections will be noted under traffic. New series of slabs have likewise been laid at Arlington Farm, comprising a number of reinforced concrete sections and a number of sections with bituminous tops. These will be subjected to impact in much the same manner as I have described.

Another investigation which promises important results is that of the causes and elimination of corrugating or "washboarding" of gravel road surfaces. Parties have been in the field during the past summer

in Maine, New Hampshire, Massachusetts, Connecticut, New Jersey, Wisconsin, and Michigan. Under the action of traffic, corrugations form in many gravel roads, the distance between the crests of the waves being 25 to 36 in. and with a normal maximum height of 1.5 in. It seems to be the case that such corrugations very readily develop in gravel surfaces under 30 ft. in width under a traffic more than than 400 vehicles per day, and much depends upon the character of the gravel and its binding material.

It will be noted that the experiments which have been described aim to establish fundamental principles in connection with the design of roads. As you all well know, in the past too little thought has been given to the various conditions which should be taken into consideration in deciding upon a proper road design. Too much reliance has been placed upon the behavior of an apparently similar road which, however, may be subjected to entirely dissimilar conditions. Let us establish the art of road building as an exact science and to this end let us obtain and use the underlying, fundamental facts.

Efficient Methods of Providing for Traffic During Highway Construction*

By A. R. HIRST†

Many of us, working in our small individual fields of highway work are a little apt to lose sight of the fact that during these last few years and in the years to come, we are going to live through one of the greatest romances of all engineering history. We are too apt to localize our viewpoint to our especial field in this work, but it is true that in these American states we are undertaking the greatest engineering enterprises in the history of the world, in this attempt to build a highway system. The Bureau of Public Roads says that we are going to spend on federal, state and county highway work this year, $700,000,000. This is a lot of money and in the expenditure of it, we, as engineers, are expected to see that it is honestly and well done, but we feel in Wisconsin that life is not worth living unless, as you go through it, in addition to performing that work which we must perform, we get some pleasure out of it. After all, as we pass through life, we engineers can never hope to gain any money. The only thing we can gain is the consciousness of doing well those things we have to do and to have a little fun and pleasure as we go through with our work.

The difficulty which we will have in building up this highway system is not in its essentials, a difficulty in regard to performing the work itself. Not to brag about it at all except to indicate the magnitude of these accomplishments in these great middle western states. In 1921 we built in Wisconsin 3,600 mi. of road, including 340 mi. of concrete, and 2,300 mi. of gravel, and incidentally, we threw in 800 bridges over 10 ft. in span. But these things did not bother us at all. The thing which bothered us and which bothers all of us is the attitude of the public toward this great public enterprise. The railroads in the five years between 1879 and 1884 built several thousand miles of railroad but they did not build within that period one quarter of the highway mileage that we are building during the present five years and they did not spend one-fourth of the money. The paid engineering talent quite well in those days. They turned them loose on the construction and, in general, the construction was performed as a straightforward engineering matter.

While we are drifting somewhat away from the subject, I wish to say that the most important American highway problem today is whether we can educate the American people to appreciate the magnitude and the importance of this job. Prof. Blanchard kindly stated that I was a fighter for higher salaries. I am, I have been, and I always will be. Not because I want more money myself but when the State of Wisconsin is spending $30,000,000 and every other American state of any wealth is likewise spending millions, it has become a matter of the greatest importance that this money be spent honestly and well by engineering organizations of skill and efficiency. After all, the people of the states are going to get just about what they pay for and the counties the same, and so, also the smaller governmental divisions.

The best paid highway organization in the United States, considering relative responsibilities, are some of the county highway organizations. The next best or I should say worst, paid are the state organizations, and the very worst paid are the Federal men. Our good friend, Thos. H. MacDonald, a wonderful man and engineer, receives the munificent compensation of $6,000 a year. We must by every means in our power fight for progress in this matter. We must fight for the proper standards of organization and efficiency. We must concentrate upon this and "ding" at it insistently because if we are going to spend at the rate of $700,000,000 a year and more for highways, the organizations which spend it can not be too efficient, and efficiency is just another word for well-paid organizations.

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*Paper presented at Eighth Annual Conference on Highway Engineering at the University of Michigan.

†State Highway Engineer at Wisconsin.

The politicians in America have played with the highway game for several years. Some of them have found that it is a very expensive thing and a dangerous thing to play with and those states are clearing up. But until the governors of all the states learn that here is one thing which they can not afford to meddle with in a political way, the American people will continue to have very expensive lessons. As a matter of fact, it is astounding they have not gotten worse than they have so far. It speaks well for the honesty and efficiency of the engineering profession which has given to the states and counties the service which they have received, at the price they have paid. We are meeting in the engineering field a very severe competition from contractors and material and machinery companies. The state legislatures have not awakened to the fact that this is about the sole public enterprise in which the state and counties are in a competitive field. They are so used to having as officials, largely men who could not make a living in any other way, that it has gone down the line that a man who is employed by the public must necessarily be a loafer, a grafter or an incompetent. We must teach and preach that this highway enterprise is entirely different from the ordinary run of public offices, which are usually held in America either by men who have been or by men who hope to be. We want the highway field to be covered by "is-ers." We are trying to build up organizations which will be a permanent field of service for the life-work of young men, and if we are going to attract the best young men we must offer the proper environment in which they are to work.

In talking highways we are too apt to think of highways in terms of specific details. The romance of the highway game, the thing which keeps me in it 16 hours a day, is the fact that we are seeing develop before our eyes, the greatest growth of transportation ever known in the history of the world, and we are supposed to take care of it from day to day and from year to year. We have in Wisconsin approximately 350,000 motor vehicles. They travel over our highways 1,250,000,000 mi. a year. If we can save them one cent a mile, it wold mean a $12,500,000 a year saving to this traffic. When I started out in the highway game something like 14 years ago in Maryland when we had few automobiles, we built waterbound macadam roads at a cost of about $4,000 a mile and we thought they would last forever. The same kind of a highway that we built in Maryland would last about two weeks on one of our main traveled roads today. This mass of transportation service which we must oversee, exceeds the railroad transportation. We accommodate more passengers than all the railroads in Wisconsin combined, ten to one. All kinds of railroad trains run 13,000,000 miles a year in Wisconsin and our motor vehicles run 1,250,000,000, so you see it has become a problem of magnitude. We must build highways as fast as we can get our taxpayers to pay for them. We must recognize the fact that highway traffic is the thing to be served and that the details as to whether we build 1,000 or 3,000 miles each year is rather immaterial. The thing to get hold of is the matter of serving traffic, not five years from now but right now.

In Wisconsin we started in 1918 by taking over a system of 5,000 mi. of highways just in the condition it happened to be in. We have maintained them from that time, adding 2,500 mi. two years ago. In addition our counties are maintaining 5,000 mi. of secondary roads, making a total of 12,500 mi. of road maintained in Wisconsin under the patrol system. We spent last year $4,000,000 for maintenance and $24,000,000 for construction, but if I had to stop either construction or maintenance, I should see that the maintenance was kept up, because in that way we can accommodate a greater number of people. When we took over the system in 1918, a man could average about 15 mi. an hour in the summer season. Today we divide the distance by 25 and that is the number of hours it takes to cover the distance, and we can even do a little better in some sections. Michigan has duplicated these results and so has Minnesota. We have all simply tried to do the best we could with what we happened to have when we took over the systems.

I have often said that the minute a state or a county adopts a system of highways which it says it is going to construct some time, upon that day it must take over the maintenance of that system. Some of the Eastern states, on the other hand, have been building a highway system for decades. They have almost finished them now and there has never been a period in the meantime that one could go from one end to the other of those states without getting stuck in the mud at the proper seasons of the year. The states maintained the roads they had built but the roads which they had not built were not maintained. That policy is wrong. Just as the Michigan Central or the B. & O. or the Pennsylvania seeks first to get the traffic through at almost any cost, just so must the states and counties get their traffic through first if they possibly can, and it is surprising what can be done if you will only persistently keep after them.

A concrete road is a wonderful road. We have about 1,000 mi. of it. We built about 350 mi. last year and we expect to build about as much more this year. We are building hundreds of miles of gravel roads. But although we started in highway work in 1907, after all these years, of the 7,500 mi. of the most important highways, we have surfaced about two-thirds and of the mileage surfaced, less than 13% is concrete. So we will have a long ways to go. When the state aid law became effective in 1912 several counties were opposed to it because "they said they had built their roads and they did not wish to help other counties to build theirs." But four of these counties have bonded during the last year to build concrete roads, since the

roads they had are not adequate for the traffic upon them. Hence, that is one advantage in our work. It is never done. We have always either to rebuild old highways or to build more of them. But we can justify that we have spent on roads in the last few years and we can also justify the building we did 10 or 15 years ago.

We have got to simply sell this romance of ours. We have got to concert the people from thinking of the thing merely as a matter of dollars and cents. There will be no complaint if we deliver to the people one hundred cents on the dollar. Our highways do not come from a state highway department or from a university. They come from the legislatures of the states. They come from the county boards in the various counties. There is the crux of the situation. There is where the money is provided and the laws made which make it possible for us to build roads and there is where the conditions under which we are to operate, are created.

If more engineers would turn their attention to this end of the game, the matter of the education of the public, the legislatures and county boards, which after all reflect the desires and purposes of the people, and possibly a little less attention to the science and theory of construction, concentrating themselves upon this for the next three, four, or five or ten years and educating the public to an appreciation of this public work, we will get our results a good deal faster and easier. I am familiar with the highway results in America. I know what we are doing in the middle west and I had the pleasure of taking a trip through the Eastern states and I came back from that trip very well satisfied that, after all, the American people have gotten pretty good value out of all they have spent for highways in the last five or ten years, whether the roads were built of gravel, macadam, concrete or brick. In general, they were giving all the service they could or expected to give and the American people will get out of them all they put into them and more.

We have had too much worry about the millions of dollars that have been wasted. Very few of them have been wasted. States which like Wisconsin and Minnesota and Michigan have built large mileages of low type roads, gravel and macadam, for which we have been criticized, in most cases got those roads complete, including surfacing and culverts for less than the grading and culvert work could be done for today. They have had these surfaces all these years and they will make a good foundation for future work. They talk about some of our old concrete roads in Wayne County and Milwaukee and others as having cracked badly. They are worth more now as a base for any other kind of pavement we may wish to put on them than they cost ten years ago.

Next after the necessary education of public sentiment, the most important thing, in my opinion, is that we should consider the problem of proper locations of highways. If the states have lost anything in their highway investment, it has been that we have not looked far enough into the future. We have not located well enough. Let us get into figures. A highway which carries 500 vehicles as a maximum a day in the summer season and drops off the rest of the year is a light travelled highway, but even on this highway one mile of extra distance costs travel over this road approximately 123,250 mi. a year and the cost of this extra traffic at 10 ct. a mile is for each mile the interest at 5% on $246,500. Take the matter of detours. The question is whether to put in a detour or accommodate traffic by building a temporary road or bridge. Taking the average summer road in Michigan or Wisconsin with 500 vehicles a day, a 3-mi. extra detour means 1,500 mi. a day. If the road is closed for 90 days, it means $13,500. Those are the kind of figures we are dealing with. The cost of highway traffic is paid by millions of people. We have just exactly the same problem in taking care of this traffic that the railroad has in taking care of its traffic. We can lose just as much as they by the unskilled handling of this traffic. In my opinion, in many cases, rather than to use a bad detour, it would be much better to ditch the old right of way and build a new road parallel to it and let traffic use the old road while the construction of the new road is going on. It would cost the people less money, and the same is true of bridges. In Wisconsin we are locating the highways so that, whenever possible, we build the bridge parallel to or near the old bridge, using the old bridge while constructing the new one. It is sometimes very hard to educate the people to that state of mind. They do not realize when they are saving and when they are losing money.

I made the statement at Omaha that the state highway department which was not being severely criticized because of its drastic relocations and treatment of distances, curves, and railroad crossings was failing in its duty as a state highway department. The Wisconsin department is severely criticized. The people think some of our plans are too drastic, but for the 50 years between 1860 and 1910, the farmers and the towns of Wisconsin were so busy in unrelocating highways, that we have had an awful time to catch up with them. It was the era of squaring fields and time after time, to the extent of dozens of miles we have bought back from the farmer the old right-of-way on which the pioneers put the highway, but which was later abandoned in order to square fields. What they took from the public for nothing we are buying back and paying thousands of dollars for. The location of gravel roads is not quite so important but concrete roads cannot be located too well. There is no reason to believe that we are any more foresighted now than we were five years ago. I don't believe that any state highway department con get away with a program of highway location which is too drastic because before they do they

(Continued on page 242)

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

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Editor

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Copy for advertisements must reach the New York office by noon on Tuesday of the week before date of issue if proofs are to be submitted.

Copy for classified and other advertisements where proofs are not required will be accepted until noon on Monday of the week of issue.

Articles by road builders are solicited. They should be short and, if possible, accompanied by photographs. Those accepted will be paid for at current rates.

Vol. LXII April 26, 1922 Number 17

HIGHWAY RESEARCH

Looking back upon the marvelous industrial and commercial expansion of this country during the past fifty years, one is at once impressed by the important part scientific research has played in this growth. Where formerly hit-and-miss methods were employed, industrial processes are now based on scientific knowledge obtained by experimentation.

It is no reflection upon highway engineering to say that the underlying principles of road design are not yet fully understood, for only a few years have passed since road building became a matter of engineering. Before the advent of the motor vehicle the problems of road construction were few. Yet in a score of years motor traffic has increased so that now approximately ten million motor vehicles are traveling on the nation's highways. The problems brought about by this tremendous increase in traffic have not been constants, but variables. Thus does highway engineering differ materially from other branches of engineering. A problem in mechanical engineering is a constant, whereas a problem in highway engineering is a variable, to be solved progressively. When the highway engineer built roads a decade ago, he built them to serve a type and quality of traffic essentially different from that obtaining at the present time. The highway engineer has been swimming against the tide and under the circumstances has done remarkably well in caring for the transportation needs of the country. Great progress has been made in road building in a comparatively few years.

Modern motor traffic, that of heavy trucks particularly, is attended with many highway problems difficult of solution. Pavements can not be rationally designed until the forces acting upon them are thoroughly understood. The work now being done by the U. S. Bureau of Public Roads and some of the state highway departments will do much to clarify the question of road design. Elsewhere in this issue appears the second installment of an article by A. T. Goldbeck, Engineer of Tests of the U. S. Bureau of Public Roads, describing the research work being conducted by that bureau. Among the matters under investigation are, influence of impact of motor vehicles on road surfaces; temperature stresses in concrete pavements; bearing power of subgrades of various kinds of soil; methods of draining roads; relative wearing qualities of different types of surfacing. It is unnecessary to point out that a clearer understanding of these matters will enable road builders to do their work more efficiently and economically.

Incidentally, it may be said that highway research will not discover an "ideal" or "permanent" type of road construction. Research will undoubtedly enable engineers to build better roads, but it will not open the way for the construction of roads that will last forever. There has been much clamoring on the part of the public, especially automobile associations, for "permanent" roads—roads that will not wear out. Just why motorists should expect pavements to last for all time is not apparent, especially in view of the fact that the vehicles which operate over these highways are relegated to the junk pile in a very few years. One never hears the cry for "permanent" or "ideal" motor vehicles. It is taken as a matter of fact that motor vehicles are subject to the laws of matter. And even among engineers the thought sometimes exists that pavements may be made "practically indestructible." To our mind such hope is unjustified. Road research will open the way to the construction of more durable highways, but it will not enable engineers to design highways that will endure forever. Highway research seeks information "which will lead to the more rational design of road systems that will serve traffic with the utmost economy. It should be emphasized that our roads should be planned not only to sustain the traffic without premature failure, but should be regarded as merely an essential part of a system of highway transportation, just as a railroad track is merely a part of a railroad transportation system. The roads and the vehicles traveling over the roads should be so suited to one another—not that the road surface will be most conserved, and not that the vehicles will be able to travel over them with the least possible vehicle cost—but that ultimate transporation economy will result. In other words, we have in mind that after all, our main object should be to accomplish highway transportation with the least cost to the general public who are paying for all the items of vehicle cost and highway cost involved in that transportation.

EFFICIENT METHODS OF PROVIDING FOR TRAFFIC DURING HIGHWAY CONSTRUCTION

(Continued from page 240)

will be overturned. The art in this business of highway construction and maintenance and location is to go just as far as you can possibly go and get away with it. Sometimes some one goes too far and don't get away with it. The thing we want to look out for is that we are steering close to the rocks all the time in this matter of proper location and proper widths and proper types because only in that way can we be sure that we are somewheres near right and that our successors will not criticize us for being blind to the probable development of traffic.

We are all going more and more into maintenance and into the things which accommodate traffic. One of the most important things is to properly guide the traffic and to do this we have published for several years a state trunk highway map of Wisconsin. We have issued and sold each year over 40,000 of them. In addition to being engineers we have become map makers and salesmen. This year we are going to change our map so it will show the type of the highway, so that one can tell what kind of a road he will find in any direction and can choose the best to travel over whatever the kind of weather. Also last summer we started a detour map service. We issue this map weekly. It shows the roads under construction and roads open to traffic and the detours. These maps were posted at about 80 garages and hotels around the state and any one can look over the routes and find out just what trouble he may encounter if he chooses a certain route or what trouble he may avoid by choosing another. This information comes in from our district offices on Monday of each week, the corrections are made in our main office and the maps are mailed out Wednesday, so we give reasonably quick service. This public service is just one of very many new phases of highway work.

In my opinion, of all the lines of civil engineering, (if a man really goes into it with vision) highway engineering offers the most wonderful opportunities for true engineering accomplishment that were offered in the history of mankind. While money is a good thing, the American highway engineer who has lived through the last decade or will live through the next decade will have, when he is done, at least the conviction that he has performed a real service to the American people and that counts for a good deal. If one is able to die in the conviction that he has really contributed something worth while to the development of these great American commonwealths, he will feel that he has not lived in vain.

COST OF HIGHWAY CONSTRUCTION

The long diagram in the next column shows the cost per square yard of laying eight different kinds of pavements in nine different sections of the country on some 12,000 mi. of highway completed to last December, with the assistance of federal aid under the jurisdiction of the Bureau of Public Roads.

The cost of each kind of pavement varies considerably among the different geographical districts, the most uniform in this respect being plain concrete. As might be expected the sand and clay road is the cheapest, and brick the most expensive.

With respect to average cost, bituminous concrete, plain concrete and reinforced concrete are very nearly on a par. It is not true, however, that that pavement which is cheapest in one section is cheapest in all. For instance, reinforced concrete is cheaper than plain concrete in the west, south, central and Pacific districts, but more expensive in the five other districts. While in the west, south, central district, brick pavement is cheaper than either one of the three kinds of concrete pavement, although in the other four districts in which it is used, brick is the most expensive.

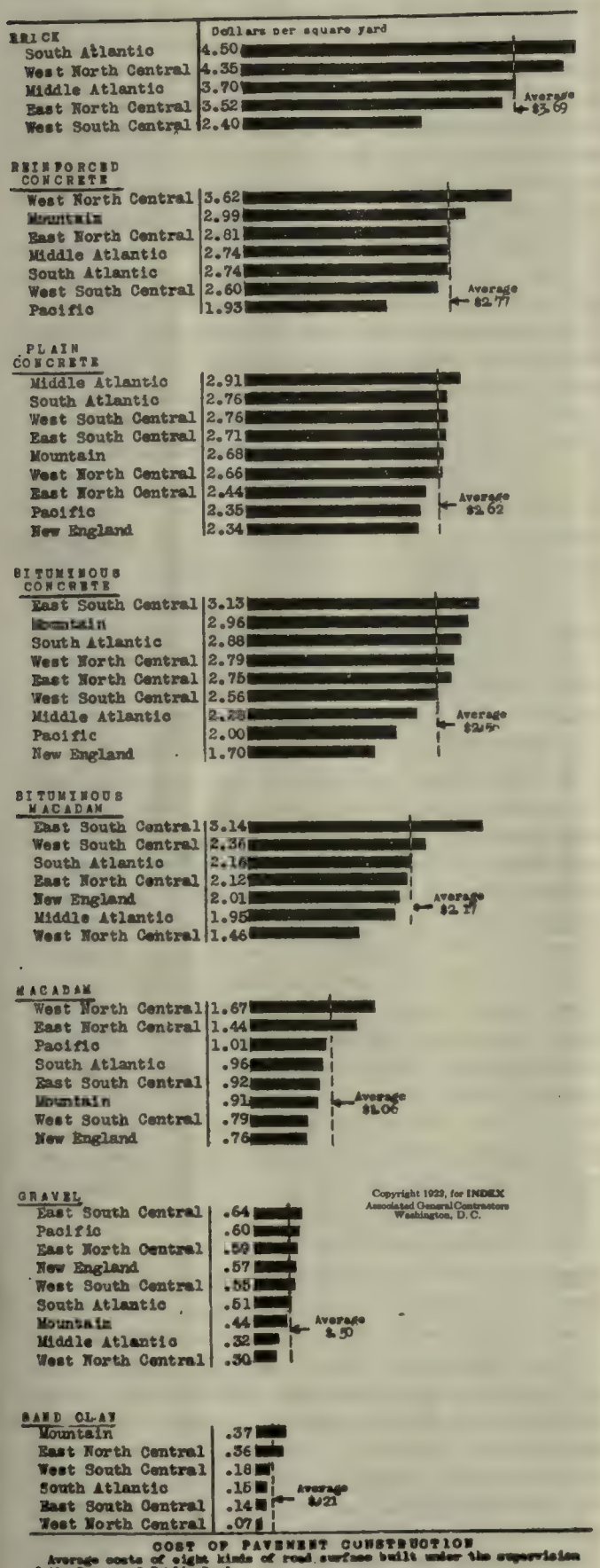
WAGES IN ROAD BUILDING

Average rates paid in February on Federal Aid work in cents per hour

Section of Country	Kind of Work	FOREMEN			OPERATORS												SKILLED LABOR		
		Superintendent	Foreman	Bus Foreman	Auto Driver	Motor Truck Driver	Roller Engineer	Machine Driller	Mixer Operator	Elec. Shovel Operator	Tractor Operator	Concrete Finisher	Crane Operator	Engineman	Blacksmith	Bridgeman	Carpenter
East North Central	Grading	66	50	70						75				41	40		50
	Paving	84	58			48				65							
	Structures	65	50														
West North Central	Grading	70	51			42	50			100	56			60	50		40
	Paving	81	49			40	40			70							
	Structures	90	54			42			45		50			50			52
South Atlantic	Grading	67	39			30				60			67	53	25	100	50
	Paving	150	52			45									27		
	Structures	100	51	30	25	25	58		35						35		42
East South Central	Grading	93	49	55		35	50			90		52			30		
	Paving	80	56		28		58		30					25	50	60	29
	Structures	100	65	55		35			27								
West South Central	Grading	72	54	77	40	33		40		133	65	28		68	40		68
	Paving	104	63	71	31	35	55	48	62	57	44	46	100	61	46	48	49
	Structures	80	56	70	27	35			34			62	62		48		
Mountain	Grading	106	70	63		54	44	55		125	65			61	62		63
	Paving	103	58	65		55	52							50	50		62
	Structures	94	73	72		50			55		30			53	67	50	
Pacific	Grading	118	72	61		62	73	58	100	106			87	62	63		75
	Paving	112	85	62	62	72	75		75						60		78

Section of Country	Kind of Work	SKILLED LABOR							COMMISSARY LABOR					COMMON LABOR		TEAMS	
		Bridge Carpenter	Driller	Fireman	Plasterer	Concrete Finisher	Mason	Pavement	Cook	Assistant Cook	Cook's Helper	Plumber	Waiter	Common Labor	Teamster	Team	Mechanic
East North Central	Grading													23	22		
	Paving	50		45					52			10		24	42	28	40
	Structures													30			
West North Central	Grading													28	27	40	
	Paving								60					28	22	31	60
	Structures			35										32	20	38	50
South Atlantic	Grading													15	12		
	Paving								10					16	12		
	Structures			20		30								16			30
East South Central	Grading													20	18	34	
	Paving	50			45	67	89	80						16	19	32	
	Structures													18	17	42	50
West South Central	Grading	35	20	34	25	62	50	43	31	22	25	18	35	24	24	42	
	Paving	20			35	53		49	30	17	17	14		23	21	42	55
	Structures								31	20				24	22	24	66
Mountain	Grading		48	88	50			60	61	60	30	50	50	39	33	35	
	Paving	58					47		36	35		20		35	35	68	70
	Structures								36					36	32		
Pacific	Grading		47	75	75			75	60		25			45	46		
	Paving					69			40		25			50	45		
	Structures													46	45		

The tabulation below shows how the labor cost involved in the building of these pavements and in the other work of road construction varies from district to district, as well as the variations between occupations or trades.—From "Index," published by the Associated General Contractors of America.



COST OF PAVEMENT CONSTRUCTION

Average costs of eight kinds of road surface built under the supervision of the Bureau of Public Roads.

THE NEW MOTOR TRUCK REGULATIONS IN NEW YORK

Governor Miller of New York has signed two bills passed by the 1922 legislature which contain new and drastic regulations in regard to the weight and character of motor trucks that may be driven on the highways of the state and a considerable increase in the registration fees of motor vehicles.

The Lowman Bill, signed April 7 and effective at once, increases the gross load that can be carried on a four-wheeled vehicle from 25,000 to 28,000 lb. and reduces the allowable weight on one wheel to 9,800 lb. The carrying capacity of tires is reduced from 800 lb. per inch in width to 700 lb. and the width of pneumatic tires is defined as the greatest width of the tire casing. A new provision prohibits the use of any rubber tire which is worn to less than 1 in. above the metal flange.

The bill limits the width of body of motor trucks to eight feet except in the case of racks for carrying empty boxes, barrels, and baskets or hay, straw, and unthreshed grain.

The speed of motor trucks with solid tires, not exceeding two tons capacity, is now limited to 20 mi. an hour; in excess of two tons capacity, to 15 mi. an hour. When the truck is equipped with pneumatic tires, 5 mi. an hour in excess of these rates is permitted.

The provisions in regard to equipment provide that all motor trucks and buses must have a rear vision mirror and that the weight of the vehicle, manufacturer's rated capacity, and gross weight must be legibly shown on the right side of body or chassis or on the right side of the cab below the driver's seat.

The State Highway Department is authorized under the new law to inspect motor vehicles to detect violations of the motor vehicle law and to use state police for that purpose. The penalties for overloading are very heavy and include the power to compel unloading of the excess weight by the roadside.

CEMENT MANUFACTURERS ON TRIAL

Several witnesses have been examined by the government so far in its suit against the cement manufacturers of the Eastern district before Judge Knox in the United States District Court in New York City. The government is seeking to prove that 19 corporations, some of them the largest manufacturers of cement in the country, have fixed prices and curtailed production through the Cement Manufacturers' Protective Association. Much time has been consumed in reading into the record various correspondence between member companies of the association and excerpts from minutes of its meetings. The case is being continued.

Maintenance of Gravel Roads*

By A. H. CUNNINGHAM†

The subject of gravel road maintenance is a subject of vital importance to that part of the state which is fortunate enough to possess local deposits of gravel for road use: how important can well be illustrated by my own county and those immediately surrounding. Buena Vista county has at present a mileage of 157 mi. of gravel road on the primary and county systems, and between 20 and 30 mi. of gravel on the township system in the shape of secondary graveling districts. The surrounding counties to the north, east, and south are in about the same condition; gravel maintenance is therefore a live topic in this section of the state. In a larger sense it is now possible for a motorist to travel from Spirit Lake to Des Moines on gravel, and some pavement, not much; again broadening out the gravel maintenance problem.

Gravel maintenance readily divides into two main heads, gang maintenance and patrol maintenance.

I am going first to discuss gang maintenance, again dividing into two heads, road reshaping and the application of maintenance gravel; two heads which are so closely related that they are about as hard to separate under the actual working conditions as are the famous Siamese twins. I have about reached the conclusion, that reshaping should not be done without the placing of maintenance gravel and neither that maintenance gravel should be applied without first reshaping the road grade. We have reshaped gravel roads without applying maintenance gravel and have applied maintenance, but neither job was an outstanding success.

Reshaping can be readily done and well done with a 12-ft. blade and back sloper attachment, together with a scarifier or scarifier attachment for use on the old gravel crown; and in addition thereto a tractor of at lease 25 h. p. on the draw bar. This reshaping of grades is a job requiring an experienced grader man and one of considerable judgment and ingenuity, who is not afraid to put a grader in any old position. It means first the scraping of the old gravel to the center as much as possible, then the cleaning of the ditches and the depositing of this dirt on the grade, usually of the shoulders and close to them, and finally the spreading of the old gravel outward over the dirt, usually accompanied by the scarifying of the crown proper. A good operator will leave a clear, sharp shoulder free from the ditch trash which often bothers; and this shoulder is the very thing essential to the appearance and success of the gravel road. By the way, it is impossible to build a good shoulder with a grader to correspond to the standard primary road cut section so that our old cuts present about the same cross section next to the grade as do the fills; a slope not flatter than one and a half to one. We would all have less trouble with traffic tearing off and running down the shoulders in the cuts if the cut cross section did present a steeper slope so that traffic could not ramble down on the slope. What is the logic at easy side slopes for a little ways in the cuts when we have miles to fill where any fool knows he must not drive off the grade? Can't a man stay on a 29-ft. grade in a cut as well as on a fill? Is it not simply the relic of a past age when the road was designed so that a runaway horse could not tip the buggy over? We have found that the most careful job of reshaping an old gravel road will still mix the dirt and gravel so that maintenance gravel is soon necessary; likewise that practically no gravel road is in condition for maintenance gravel without reshaping, hence my former assertion that reshaping and maintenance graveling are practically inseparable.

The next head to be considered is the placing of maintenance gravel and here we find widely different opinions as to amounts necessary, quality of material desired, proper methods of application, etc., etc. My personal opinion is that 500 cu. yd. per mile, of a material free from large pebbles, applied to a grade with very little crown, and uniformly distributed over the grade is the proper dose of maintenance gravel for the average primary gravel road in Iowa. Five hundred yards per mile has proven to be an adequate maintenance coat without interfering materially with the passage of traffic and the finer grades of gravel have given the best satisfaction. Actual experience has shown that the life of the road is much longer where the crown is slight so that the wheel action does not chop and throw the material into the ditches, but rather, that the road is covered by a layer of loose material which is continually worked back and forth in maintenance. I note that the maintenance gravel is spread on one side in some localities and then brought over the entire grade with a blade but cannot see the reason for this system as our experience has been that a uniform spreading at the time of application produces a good high speed road at once, with traffic in the middle where it belongs.

The next matter is the main head of patrol maintenance, upon which we all disagree to some extent, and with which none of us are as yet satisfied. We will agree that gravel roads need much dragging and that this dragging is best done during a rain or immediately after, likewise that the present trend of dragging is too much toward the center which produces excessive crown; although we disagree as to the class of machinery best adapted. Some prefer light drags, some heavy drags, some multiple blade maintainers, and some patrol graders. They all have their ardent advo-

*Paper presented before Iowa Engineering Society.
†County Engineer, Buena Vista County, Iowa.

cates and can all show good results. Personally, I lean to the multiple blade maintainers pulled by army truck equipment or tractors that will do at least 4 mi. per hour, if there were but some satisfactory solution of the operator problem. These maintainers, if properly designed, and properly handled, will surely produce very good results in that they tend toward the elimination of the waves we hear so much about and can also be made to cut and deposit at any point on the road; our usual way of setting them being to cut slightly on both shoulder and crown and to deposit on the quarter point between. On the other hand their operation is but a part-time job for the operators unless patrol districts are made so long that all parts cannot be reached soon enough after a rain; and it is impossible to hire good operators part time. Again, the road under their care will not receive the little attentions which roads, like wives, need, they say. The next best thing then, is the two horse patrol outfit, with its own small section of the road for which the patrolman is personally responsible. He can do all the dragging work with his patrol grader and then can then spend the remainder of his time in hauling maintenance gravel and doing the thousand and one things which should be done to maintain a road well; culvert, ditch, and intake cleaning, weed cutting, the pulling of young trees from the cut ditches, repairs at intersections care around bridges and culverts, etc.

BATES EXPERIMENTAL ROAD TESTS

The first stage of the final tests, which are being conducted by the Illinois Division of Highways on the Bates test road, was completed April 5 when the loaded trucks had made 1,000 round trips over the 63 sections of the 2 mi. road. Failures in ten sections resulted, but the conclusions to be drawn from these failures are uncertain until the full record of the completed tests is available for study.

For the first 1,000 trips the trucks were stripped so that the load on each rear wheel was 2,500 lb. and, on each front wheel, 2,250 lb. This corresponds to a nominal load of 250 lb. per inch of tire and 450 lb. per inch of tire.

The trucks made regular trips up one side of the road and back on the other side at a constant speed of 15 mi. per hour. A path of travel was maintained so that the center line of the outside rear wheels was 6 in. from the edge of the pavement on all sections except those having macadam base. On the latter, the first 500 trips were made with the trucks traveling near the center of the pavement except at passing points. The last 500 trips were with the center of the wheels traveling at a distance of eighteen inches from the edge of the pavement.

The effect of the traffic was noted by eight station observers who made minute records of all cracks, depressions and other indications of failure and matters of general interest. All breaks and other defects which appeared were immediately painted and detailed sketches recorded.

The testing has been temporarily suspended on account of unfavorable weather conditions. When it is resumed, the next increment of loads will be such that each of the rear wheels of the trucks will carry 3,500 lb. and each of the front wheels, 2,300 lb. With this increment, 1,000 trips will be made.

TYPES OF CONSTRUCTION ON LINCOLN HIGHWAY IN 1921

The states and counties traversed by the Lincoln Highway expended $7,730,000 in new construction on that route in 1921. The following table shows the mileage of each type of construction completed last year, the total being 12% of the mileage between the two coasts:

Type	Miles
Concrete	99.51
Brick	21.35
Bituminous Macadam	5.83
Gravel	174.85
Sand Clay	4.25
Permanent Earth Grade	91.77
Total	397.56

The total mileage of improved sections of the Lincoln Highway at the end of 1921 is 3,305 mi.

MINNESOTA TO SPEND $30,000,000

Statistics compiled by the Minnesota Highway Commission show that approximately $30,000,000 will be spent on road building in that state in 1922. The estimated income for highway improvement includes $5,650,000 from motor vehicle taxes, $2,563,000 federal aid funds, $2,400,000 county reimbursement bonds, $2,200,000 state aid apportioned to counties, and $18,000,000 local appropriations by counties, villages and townships. The work which is to be done with this money includes 130 mi. of pavement, 684 mi. of gravel surface, and 386 mi. of grading. The patrol system for maintenance, which calls for one patrolman for every 5 mi. of road on which state money is spent, will give employment to about one thousand men and will cost approximately $2,225,000.

WOULD HAVE STATE CEMENT PLANT

The Little Rock Chapter of the American Association of Engineers has presented to the Governor of Arkansas a resolution which requests him, in as much as the prevailing price of cement is entirely out of proportion to the price of other construction materials, to initiate an inquiry into the feasibility of building a state cement plant to be operated with convict labor, thereby securing, at minimum cost, cement for use in public road and street construction.

MEETINGS

Calendar of Coming Meetings

May 12—National Highway Traffic Association—Annual meeting, Automobile Club of America, New York City. Secretary, Elmer Thompson, 247 West 54th St., New York City.

June 4-6—American Association of Engineers—Annual convention, Salt Lake City, Utah. Secretary, C. E. Drayer, Chicago, Ill.

June 13-16—Canadian Good Roads Association—Ninth annual convention, Victoria, B. C. Secretary-treasurer, George A. McNamee, Birks Bldg., Montreal, Canada.

June 26-July 1—American Society for Testing Materials—Twenty-fifth annual meeting, Atlantic City, N. J. Secretary, C. L. Warwick, Engineers' Club Bldg., Philadelphia, Pa.

Oct. 9-13—American Society for Municipal Improvements—Annual convention, Cleveland, O. Secretary, Charles Carroll Brown, St. Petersburg, Fla.

DIXIE HIGHWAY ASSOCIATION

The annual convention of the Dixie Highway Association will be held at Jacksonville, Fla., on May 26 and 27. A large attendance is expected because there is more construction activity on this route than ever before.

BRICK VARIETIES REDUCED TO SEVEN

The standing committee of the U. S. Department of Commerce on Simplification of Variety and Standards for Vitrified Paving Brick met in Washington March 27 and eliminated four of the remaining 11 types and sizes.

Those finally decided upon and remaining as "recognized types and sizes" are:

Type	Dimensions	Depth as Laid
Plain wire-cut	3x4 x8½ in.	3 or 4 in.
Plain wire-cut	3½x4 x8½ in.	3½ or 4 in.
Repressed lug	3½x4 x8½ in.	4 in.
Wire-cut lug	3½x4 x8½ in.	4 in.
Wire-cut lug	3½x3½x8½ in.	3½ in.
Wire-cut lug	3½x3 x8½ in.	3 in.
Repressed hillside	3½x4 x8½ in.	4 in.

The conference of 1921 was called by Secretary Hoover as his initial move in a campaign to eliminate waste in industry and was attended by representatives of the principal national engineering organizations. At that time, 55 out of the 66 sizes and varieties then being manufactured were eliminated and a committee appointed to consider further reduction as time went on.

The Committee decided to make no further eliminations before March 1923, when shipments for 1922 could serve as a guide.

HIGHWAY POLICY OF IOWA FOR 1922

The Iowa State Highway Commission in a statement of their policy for road work in 1922, recognizes the fact that the people of Iowa have not for many years been so critical of expenditures involving public funds as is the case today. Consequently, it recommends a conservative program of highway improvement which will make use of only those funds which have already been made available and which can be used for no other purpose. They feel that it is time to decrease expenditures that must be paid from direct taxation and to strive to secure the maximum amount of road improvement for expenditures that are made.

PREFERENCE FOR EX-SERVICE MEN

Contracts recently signed by the Wisconsin Highway Commission, which call for the construction of 27.7 mi. of road in Brown County, contain a special clause which stipulates that local labor is to be employed and that ex-service men are to be given preference. It is expected that more than 500 men will find employment with the construction companies.

The State of Illinois recently sold $6,000,000 of 20-year serial 4% road bonds at 98⅞. These bonds are part of the $60,000,000 issue authorized by referendum vote in 1918 for a 4,800 mi. road system.

PERSONAL MENTION

E. R. Conant, Town Manager of Mansfield, Mass., has resigned to take the position of surveyor of the highway department of Manchester, N. H.

Ezra Schoecraft, City Engineer of Flint, Mich., has tendered his resignation to take effect May 1.

Julian Montgomery, City Engineer of Wichita Falls, Tex., has resigned to enter private practice. F. M. Rugely, his assistant, has been appointed city engineer.

R. T. Brown, Chief Field Engineer of the South Carolina State Highway Department, has resigned his position to become associated with J. T. Plott, of Greensboro, N. C., in construction work. Ambrose Harwell, former division engineer, will succeed Mr. Brown as chief field engineer.

J. T. Ellison, of St. Paul, Minn., has been appointed assistant state highway commissioner of Minnesota to fill a new office created by the last legislature. He will continue to hold his present position of chief bridge engineer with the commission.

Leland G. Merrill, City Engineer of Parkersburg, West Va., has resigned to accept a position with the West Virginia State Highway Commission.

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TABLE OF CONTENTS

Comparison of Sub-Drainage by Deep Side Ditches and Tile Drains. By C. M. Upham 247

Bituminous Surface Treatments on Macadam Roads. By Allan K. Hay 250

Necessity for Strong County Organization.. By R. W. Davis 252

American Road Builders' Association Annual Meeting 255

Developments in Methods of Constructing Brick Pavements. By Arthur H. Blanchard 257

Bituminous Treatments for Earth and Gravel Roads 259

Lower Cost of Road Construction 259

War Material for Road Construction 260

Repair Road with Volunteer Labor 260

Examinations for Transitman 260

EDITORIALS:

Motor Truck Overloading 255

Highway Drainage 255

MEETINGS:

Calendar 260

Conference on Traffic Signal Colors 260

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Comparison of Sub-Drainage by Deep Side Ditches and Tile Drains*

By C. M. UPHAM†

Sub-drainage is another way of saying stabilization of subgrade or road foundations. Although we may go into this subject very carefully, very scientifically, and with much detail, we simply mean excluding moisture from the roadway, or draining moisture away from the roadway. If we look over some of the earlier highway literature we find that one of the most emphasized details of construction was drainage of the highways. Nearly everyone would talk drainage and plan drainage systems, but when they commenced to construct a road the drainage system was generally excluded on account of its cost, and this money was usually spent in the construction of the surface. That this was an unwise practice has been too often proven. Considerable scientific data are now available which gives us more information relative to the regulation of moisture in the subgrade and the practice of stabilizing road foundations.

I think it is safe to say that, at the present time, road surfaces are standardized to a degree, at least, that we can practically be assured of satisfactory results if constructed in accordance with standard specifications. In many roads we have had sections of the road surface break up, while in other places it has proven strong enough to carry the traffic. Investigation has shown that the cause of the failure was not due to the road surface itself, but on account of the failure of the subgrade or road foundation. This has commenced thorough investigation of this subject, and before very long data will be collected and assembled so that the results of various researches will be made available for practice. It is practically accepted that the bearing power of any soil or subgrade will vary inversely with the amount of water that the soil or subgrade contains. With this fact to work upon it is readily seen that the more water present in any soil the less will be its bearing power or carrying capacity.

The extent of the effect of moisture on any subgrade depends upon the kind of soil in the subgrade, so that it is readily seen that the selection of soils which go to make up the subgrade is one of the most important factors in road construction. This detail is many times overlooked. In clay soils it has often been found that the soil nearer the surface of the ground is more satisfactory for subgrade construction. This undoubtedly is due to the fact that the soil has been broken up due to the action of frost, and that the finer material and colloidal matter has been washed out by the rains.

In the South there is what is known as top soil, which is a sand-clay composed of broken down rock, from which the finer colloidal matter has been washed. With the varying effects of moisture on the different materials it can be seen that the selection of soil for a subgrade is very important, and it is absolutely necessary to get a material of low capillary attraction and resulting high bearing value in the top of the subgrade. Many times the mistake has been made of taking all material from cuts and throwing it indiscriminately in the fills, whereas it would be to the great advantage of the road to select the material generally from the top of the cut and place this material on the top of the fill. In that way we would have the better material in the top of the subgrade and this would afford a higher bearing power for the construction of a road surface, which would have the same effect as increasing the depth of the slab.

There may be many methods of stabilizing subgrades. We cannot imagine any road so muddy and unserviceable that we could not build up a subgrade by putting sufficient number of rocks or crushed stone in the subgrade. We could also go to the other extreme of imagining a subgrade constructed of solid concrete, and there are other impracitcal methods of stabilizing subgrades, but on account of large mileage of roads which must be built, and on account of the comparatively small amount of money available for road construction, it is absolutely necessary that the most economic means possible be used in stabilizing the subgrade.

It has been found and accepted by road builders

*Paper presented at Eighth Annual Conference on Highway Engineering at the University of Michigan.

†State Highway Engineer of North Carolina.

that the most economic method of stablizing the subgrade is simply to take away the water from the road foundation, or, better still, keep the water from getting into the subgrade. Therefore, one of the first principles in road construction is to so construct a drainage or sub-drainage system as to pipe away all springs or water from any source whatever, so that at no time would it be possible for any of this water to enter the subgrade and thus reduce the bearing power of the subgrade.

This can generally be done by constructing ditches parallel with the roadway, the bottom of which are from 10 to 18 in. below the subgrade or foundation of the roadway. When a road is hardsurfaced it prevents any water from above entering the subgrade, at least until it has run to the edge of the pavement. The lateral side ditches intercept any water from horizontal capillarity or side seepage. There only remains then the water which rises up through the ground by capillary action. This is the most difficult and expensive water to take care of, and it can readily be seen that on account of the capillary action varying in different soils the selection of subgrade material is very important. It can safely be said that the amount of water drawn up into the subgrade depends upon the supply and the class of material in the subgrade. Generally speaking, the coarser the material the less the capillary action, and also the reverse is true to the extent that the finer the material generally the greater the capillary action, although within certain limits the capillary action in the coarser material is quicker than in the finer material, but the ultimate amount of water raised, and the height it is raised, is not so much in the coarse material as in the fine material. And inasmuch as it is the amount of water present in the subgrade which influences the stability of the subgrade, it can be seen that in selecting material for the road foundation the coarser material should be selected.

From experiments by the Bureau of Public Roads it has been determined that the capillary water in a subgrade is greatest directly underneath the hard surface slab, which means that the part of the subgrade which should be the most stable is in reality greatly reduced in bearing power. However, the problem is to substitute for this portion of the subgrade a material which is less affected by the amount of water, or which has lower capillary action, which also means, that the water does not rise so high in this particular selected material, and this is another way of saying that the subgrade is more completely stabilized by this selected material, because the amount of water in the subgrade directly underneath the slab has been excluded by the selected material.

Various cross sections of roadways have been designed for the purpose of doing away with these various conditions, and, of course, one of the universal solutions of cross sections is the side ditch, which intercepts any water from the sides, which would otherwise get into the subgrade.

This brings us up to the comparison of the side ditch and the tile underdrain, which generally consists of a ditch at the bottom of which is a pipe laid with loose joints and then the ditch filled in with crushed stone.

It has been thought by many that since this was called a drain it effectively drained all the water from the subgrade, but, undoubtedly, in many soils this drain did little or no good other than to intercept any free water which might otherwise find its way to the subgrade. In other words, it is quite likely that this drain was only effective in taking away free water which came from the surface or seeped through the ground horizontally.

It is quite doubtful if any drain ever carried away any appreciable amount of water which rose by capillary action. Therefore it can be seen that neither the open ditch nor the tile underdrain is sufficient to cope with the capillary water in any subgrade, We must, therefore, design against capillary water in addition to the longitudinal drains.

In the subject of tile underdrains there is a question as to their location. While the longitudinal underdrain will serve the purpose of intercepting water which would otherwise find its way to the subgrade, quite often transverse drains are necessary for the purpose of taking away water from springs or stratas which carry water underneath the road. The number and location of these drains absolutely depends upon conditions, and the amount of water which finds its way underneath the roadway. To carry the question of transverse drains a litle further, and to more completely develop the idea, selected material which can be easily drained is sometimes placed underneath the road surface in thicknesses varying above two inches. This material should be connected up by drainable material to the nearest drain or ditch. This is another very effective means of reducing the amount of water underneath tht road slab which is a means of increasing the bearing value of the subgrade or road foundation.

The location of a lateral or longitudinal drain has been the subject of considerable discussion. One suggestion is to place the drain directly underneath the ditch, but this seems to be the improper place on account of water flowing in the ditch carrying the finer silt particles into the drain, which gradually make it less effective. It is undoubtedly better to construct the drain higher up on the shoulder and a little nearer the roadway surface.

There are many methods now being devised for the treatment of subgrades in order to overcome the water of capillarity, and to insure more complete stabilization, various chemicals are being used to experiment in the treatment of subgrades. Water-gas tar is a substance which has been used in subgrade experi-

mentation. Other experiments show that Portland cement has an advantage in stabilizing subgrades. Experiments with low capillary material suggests that cinders, sand, gravel or crushed stone will bring about a stabilized subgrade only in a different manner. In all cases, the treated or selected subgrade material should be connected with the tile drains or ditches or drainage or drainage system, by means of the most drainable material, and the subgrade, even if built of selected material, must be so constructed as to drain as completely as possible.

We are now to the question of the comparison of the open ditch and tile drain. Neither of these is a cure-all. In some instances they help materially, but in other cases their effect is slight. There is a particular experiment which has been watched for several years. It is a surface treated macadam road. This particular road broke up every spring as the frosts came out of the ground. A complete investigation was made and what remained of the macadam surface was cleared away and, although it was expected to find a spring underneath the roadway, the only thing which was found was a layer of clay slightly over an inch in thickness. The layer of clay was slightly tilted to such an extent that water would percolate through the ground until it reached this layer of clay, and then on account of the impervious clay layer it would follow along on top of the clay and appear underneath the road surface. This amount of water on top of the strata of clay so weakened the road surface and subgrade that it broke up each year. It was noticed that this strata of clay was underlaid with a very coarse drained sand, and the water which had collected on the clay strata was easily drained down through the holes cut in the clay strata. This matter is being mentioned because in order to show that the flow of water in certain soils is very slight and that tile drains will have very little beneficial effect.

In many instances it has been found that the flow of water in different soils varies from one foot a day up to twenty or thirty feet a day in clay soils. There is some question relative to the depth of drains and ditches. It is very evident that a ditch will intercept water the same as a tile underdrain, and also the tile underdrain will have the same effect in intercepting water as an open ditch. It is assuming that both are maintained. It is quite evident that it is more difficult to maintain a ditch than an underdrain on account of the fact that in tile drains the pipe is always available for the free water, whereas if an open ditch becomes stopped up the free water is backed up and allows a bigger supply of water for capillary action in the subgrade. The deeper the ditch the more difficult it is to maintain, and one more important point is the fact that a deep ditch must be maintained by hand, which should eliminate this kind of a ditch for consideration only where the depth of the ditch is necessary for water drainage. In many instances a shallow ditch can be maintained by a road machine.

The value of a tile drain is sometimes completely lost under certain conditions of frost, and in many instances the effectiveness of a tile drain is practically of no value, although there may possibly be a very slight movement of water through frozen ground. This however, is very slight. In this particular instance, no doubt, the open ditch would be more effective, especially in taking care of any surface water, which through certain weather conditions such as a thaw, might be present.

Probably the most critical time for any road is after the ground has been frozen for some two or three feet. Under these conditions the effect of the tile drain would be greatly reduced. If this freeze is followed by a thaw the surface of the road is first affected and this condition brings about an excess of water on the surface of the road and directly underneath the slab. On account of the frozen material underneath, the free water cannot pass down into the drain and thus, in this instance, the value of a tile underdrain is reduced to a minimum. A more effective solution in this case is a shallow gutter. By this is meant a gutter from 10 to 18 inches below the subgrade with the shoulders and slopes so constructed that surface water and any free water occasioned by a thaw can readily find its way to the gutters.

It is assumed that all underdrains and ditches are consrtucted to grade and will thus quickly carry away any free water. Another very important point is that any free water which might for any reason exist in the subgrade must have a method whereby it can pass off immediately to the drain or ditch. In the case of ditches the existing conditions must be thoroughly studied before the location and depth is determined. If you are constructing a road on a fill, of course, there is no water to intercept, but in a cut which is on light grades or on the side hill work, an intercepting ditch is very effective. On the heavier grades it is not necessary to make the ditch as deep as on the lighter grades, for the grade of the roadway has the same effect as the deeper ditch. If the ditches drain readily, all indications seem to point that it is seldom necessary to construct any ditch deeper than 2½ or 3 ft. below the grade of the road. It is sometimes necessary to do so to get a suitable grade to drain the system.

In summarizing, no distinct advantage can be claimed for the tile drain above the open ditch; nor can it be said that the open ditch is more favorable at all times than the tile drain. But there are certain condtiions where a combination of the two will be the most practical. If an open ditch is used there is no advantage in making it any deeper than to intercept water, and should not be so deep that it cannot be maintained by machine; otherwise the maintenance will be a costly item. An open ditch can be used to intercept water as efficiently as a tile drain. The open ditch must be constantly maintained and presents a hazard

to traffic. On the other hand, a tile drain will serve as well as an open ditch when used to intercept water from getting under the roadway. The maintenance of a tile drain is generally less than the open ditch, although many times its original cost of construction is greater. At no time does the tile drain present any hazard to traffic, and for this reason it should be given serious consideration.

Undoubtedly no decision can be made to the extent of stating that either the open ditch or the tile drain is preferable, but it can safely be said that there are conditions when it is more economic and desirable to use either one or the other. After a careful consideration of all the details it is quite likely that a combination of the open ditch and the tile underdrain is more suitable than either the one or the other.

In no case is it necessary to construct the open ditches or tile drains lower than that point which will intercept water, for, in practically no instance do the drains reduce the amount of capillarity, and after all a combination which will most economically reduce the amount of moisture in the subgrade is the method to be selected, taking into consideration the first cost, cost of maintenance, and giving due consideration to any hazards which might be interposed on account of the open ditch.

Bituminous Surface Treatments on Macadam Roads*

By ALLAN K. HAY†

The surface treatment of macadam roads with some form of bituminous material has now become a necessity to prevent rapid deterioration caused by the surface stone being ground into dust or mud under ever-growing traffic. If surface treatments are used with discretion, the life of a road is considerably prolonged and maintenance charges are lowered. A good macadam road treated with tar or oil shortly after its construction and consistently re-treated each succeeding year will render excellent service under a very considerable volume of traffic, more especially if the bulk of the traffic is carried on rubber tires. However, heavy horse-drawn loads on steel tires are its worst enemy and in the spring of the year such a surface will cut up badly, if subjected to much of this class of traffic. On the other hand, the tires of automobiles and light or medium sized trucks have the effect of ironing out the surface and do it comparatively little harm.

Surface treatments vary in character from a very sketchy cold application of light oil or tar used as a dust-layer to heavy coatings of binder accompanied by a substantial coat of fine crushed stone.

The type of treatment for any given road can be decided only by local conditions, but in general the most successful type of surface will be one falling midway between the limits above. Partially worn out roads with surfaces showing only a small amount of exposed stone may often have their effective life prolonged a few years by an application of one of the lighter liquids without any covering material. The better class of macadam surfaces should have an application of heavier material which has been heated and should then be covered with a thin coat of stone chips, pea gravel or sand.

Of this kind of road, the mistake is often made of endeavoring to build up too thick a carpet or blanket on the road in one operation. The result is a surface which looks well and wears well for a few months and which closely resembles an asphaltic concrete or penetration built road, but in a short time this blanket of tar or asphalt pushes into waves and humps and if there is much horse-drawn traffic to cut it, will often peel from the road-metal in large areas.

This unfortunate result may be avoided by applying the bituminous material in smaller quantities, building up a thin skin coat upon which subsequent light treatments may be applied, gradually forming a tough thin film over the road. On a newly constructed macadam road, a treatment during the first season of one-third of a gallon per square yard followed by one-fifth to one-fourth gallons in the following years should, in most cases, be sufficient.

A large quantity of material is now on the market which is suitable for applying to the road without heating, but usually it will pay to heat even fairly light oils or tar products in order to secure a greater penetration into the road surface. The slight additional expense and trouble of heating is more than offset by the better results obtained.

Methods and Appliances

There are two ways of purchasing bituminous material, either in tank-car shipments or in barrels and drums. Tank car shipments are by far the most satisfactory and material should not be bought in barrels, unless the amount of road to be treated is extremely small or railway facilities are wanting.

The average tar or asphalt used for this work may be unloaded from the tank car without heating it, un-

*Paper presented before Ontario Good Roads' Association.

†Secretary and Engineer, Ontario Surburban Roads' Commission.

less the weather is exceptionally cold. Some organizations prefer to heat it in the car by means of a portable boiler connected to the heating coils and then convey it to the road in a distributor which has been insulated in some manner to retain the heat. On my own work, I have found it convenient to unload the material cold and afterwards heat it in the distributor while on the way to the place where it is to be used.

There are several standard methods of unloading. It there is a large amount of road surface to be oiled or tarred each year, and which is concentrated within a fairly compact area of country, it will pay to put in a siding with an elevated trestle, up which the tank car may be run and then unloaded by gravity into storage tanks or distributors.

However, on most work the initial cost of this installation might not be justified, and arrangements must be made to utilize various sidings located as near as possible to the work in hand. In this case a portable pumping outfit is a necessity. There are several excellent pumps on the market designed for handling various liquids of this nature, and if funds are available such a pump would be a good investment. On my own work, we use a make-shift outfit which operates quite satisfactorily under average conditions. It consists of an ordinary good plunger hand-pump, commonly known as a tank pump, operated by a one and one-half horse power engine and pump jack. As an auxiliary we use a Tarco hand pump, which is a sheet-metal affair closely resembling a bilge pump used on boats.

The motor driven pump is connected to the bottom of the car by a pipe 2 or 3 in. in diameter or by a flexible steel hose. The asphalt and tar companies are standardizing their tank cars so that a few standard connections carried in stock will fit most tank cars that are now on the railroads.

Distributors

For the usual amount of work handled by counties, especially when at some distance from the larger centres of population, a horse-drawn distributor will prove most economical. Very few counties have a sufficiently concentrated mileage of road to justify the purchase of a large unit mounted on a truck and in addition the ground in the neighborhood of our usual railway siding is of such a nature as to make it difficult for trucks to approach the tank car, more especially after a shower of rain. A horse-drawn machine of 500 gal. capacity may be operated economically on hauls up to 4 mi. and for longer hauls may be equipped with a short pole and hauled behind a motor truck. On the suburban roads near Ottawa this year we are contemplating equipping a 15-27 tractor with rubber tires for handling distributors on the longer hauls, when the tractor is not engaged on grading work. For short hauls with moderate grades one team of horses is sufficient but if there are many hills two teams will be required. By using two distributors, lower costs will be obtained. One will be filling at the siding while the other is on the road. The investment required is not large, as the average machine with jets, rotary pump, kerosene tank and burners, should not cost much over $1,000. In purchasing a distributor, an important requirement is that it shall be fitted with an efficient device for straining the liquid before it passes through the jets. If it is not provided with proper screens or strainers, small particles of sand or carbon will block one or more nozzles and cause exasperating delays on the road.

Sweeping

It seems hardly necessary to say that the road surface should be thoroughly cleaned before oil or tar is applied. A horse-drawn revolving broom is of very great value but should usually be followed by a few men with stable brooms to touch up spots which may have been passed over by the large sweeper. Applying bituminous material on a dusty road almost invariably results in a poor job.

Covering Material

Many specifications call for stone chippings or peastone as a covering material. If crushed from good hard rock, stone chips make an excellent cover, but if composed of soft lime stone the advisability of using them is doubtful, as lime stone pulverizes very quickly under traffic. Furthermore stone chips or screenings are usually not to be had, or when available needed for other purposes in the road construction.

Pea-gravel or coarse sand are the materials most commonly used. Of these I have found gravel superior as it wears better, gives a gritty surface which provides better foothold for horses and will not blow away in the first breeze as will much of the sand which is commonly used for this purpose. If screened pea-gravel is too expensive, a fine pit-run gravel may be used. It will be necessary to rake the surface of the road to draw the larger stones or pebbles to the shoulder, but this adds very little to the cost of the operation as there are often idle periods for the spreading gang while waiting for the distributor, during which two men with rakes will quickly cover very long stretches of road.

Various systems are used for handling sand or gravel. In town or city work, it may be deposited in little piles along the road, twenty or thirty feet apart, from which it is spread direct, by men with shovels. In county work on roads, where there is no curb, these small piles of sand have a tendency to shrink before the time comes to use them, as they are easily dissipated by the traffic. Another system is to dump the sand or gravel in two-yard piles, spaced 150 ft. or more apart and re-handle it from these piles, using a couple of one-horse dump carts. Five or six experienced laborers with two dump carts will cover about ¾ mi. of eighteen

foot road per day under favorable conditions. In this connection it will be found that spreading sand for this purpose is an art in which every laborer is not proficient and the success and labor cost per yard for any job is largely influenced by the skill of the men who do the spreading.

Mechanical spreaders may also be used where conditions are suitable.

The amount of cover required may vary all the way from 5 to 25 lb. per square yard and no general rule may be laid down as this is entirely a matter affected by individual conditions on each job. In general the heavier the bituminous material used, the larger will be the amount of cover required.

Costs

The cost per square yard of surface treatment is very largely influenced by the unit amount of tar or asphalt used and by its cost per gallon. Analysis of several jobs last year, where the haul was within four miles and for an application of one-third of a gallon of heated material per square yard, showed a total cost per square yard of from 6 to 7 ct. This included bituminous material, sand, labor and fuel.

Necessity for Strong County Organizations*

By R. W. DAVIS†

The building of roads is a function of government, exercised by the units forming the government and deriving authority from the enactments of the supreme unit in the state. This authority is both granted and conferred, as well as in mandatory form, prescribing the limits as well as the obligations, the powers as well as the functions of the units involved in the governmental requirements and directions. The directing power in all highway improvements and maintenance is found in legislation prescribed by the code. Our state is governed by a code of laws, and therefore neither practice nor common usage are governing factors. This legislation is planned and prescribed to coordinate the authority conferred upon the three units of government that there may be unity, cooperation and no misdirected efforts upon the part of those responsible for carrying out the intent, purpose and mandates of the law.

In this wise scheme of highway legislation there is provided the central and supervising power, conferred upon the state direct, and exercised by law through the Highway Commission.

Dipping into history, we find that prior to 1911 we had in Wisconsin a very imperfect code of highway laws, and prior to that time the towns were the only one of the divisions of government exercising any perceptible authority in road matters. We had the old town road system, and the only part taken by the counties in highway matters was the granting of appropriations in aid of the towns for road and bridge construction, and that only in what may be termed extreme cases or improvements, involving sums that made the cost prohibitive to the town in which the desired or necessary improvements was located. In the majority of the counties this unit authority was not given much attention or consideration, and it may be attributed to the fact that there was no demand upon the counties for participation in or supervision over road construction, improvement or maintenance. The road of today was undreamed of, except by the visionary.

With the enactment of the County Aid law a large number of counties awoke to the possibilities and their responsibilities and the first serious step was taken for the advancement of the good roads movement. With the enactment of the State Aid law, the dream of the visionary pioneer in the good roads movement began to materialize and the counties began to assume the privileges and functions that properly belonged to them in the building of highways. The powers were there prior to this enactment to an extent that had not been appreciated, but the enactment of the State Aid law awoke the hitherto sleeping giant of authority and responsibility, and from that awakening we have travelled the long road in the brief time and can glory in the accomplishments. We can point with pride, but we should glory in the work done, with a keen realization and appreciation of our responsibilities for and in the future.

This law, as stated, acted as real invigorator for the counties and from its somewhat imperfect form and provisions has grown the great system and results that mark our taste as the leader in progessive and efficient highway construction and maintenance. Without detracting from the prime and essential, and you may say the supreme importance and responsibility of the State in the program of road work, so wisely and well exercised and carried forward by the State Highway Commission, we must not overlook the greater and more in a way, supreme place and authority that lies in the counties, for it is after all the County that provides the initiative, and I might say in parenthesis the funds, for all the road improvements in the state.

That being the case, and the authority and responsibility being placed upon that unit in the government it has become the function and the duty of the counties to assume and carry forward the burdens placed

*Paper presented at Eleventh Annual Road School of the Wisconsin Highway Commission.

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upon them by law, burdens of legislative enactment that could not be wisely nor with justice be placed upon any other unit in the great scheme of highway legislation under our constitution and form of local government.

And this further being the case it has behooved and the counties have assumed the responsibilities and performed the duties and obligations, both legal and public, resting upon them. In this exercise of the functions and the performance of and the carrying out of the program of road improvement growing out of the intent and purpose of highway legislation in Wisconsin, the counties have arisen to the great importance of the task entrusted and conferred, and the work has been promptly and efficiently done through the county organizations provided by law and experience has demonstrated to be necessary and expedient.

The necessity then, we must assume, for strong county organizations grows out of and is a mandatory requirement of the laws placing the work of highway improvement and maintenance so largely in the hands of and upon the counties. This may appear to answer and dispose of any question or interrogation that may be contained in this subject. The task required by law is a large and responsible one, and compliance with the plain mandates of the highway enactments is a burden that must be carried as it were by the counties in proportion to their unit place in the scheme, and through the initiative coming through and from the counties and the program, boh present and future, depending upon them for the start and the impetus in the movement in highway work, the greater and supreme importance and necessity for strong county organization lies and must lie in their duty to the public. The units were formed in our scheme of government to give service, and as Mr. Hirst has so well said, we must strive to arrange the laws and practice so as to give service and to give it now, and we might add forever, as purveyors of transportation to the people.

There lies the supreme importance of all organizations, both local and superior, to serve the public, and no organization, official or set of officials can function properly unless they or it have a keen realization of their responsibility to the public. There may be limits prescribed to legal authority to be exercised by a unit of government, but there is no limit to the sense of responsibility and appreciation of duty in the performance of the very important functions pertaining to this great public work. We might digress and endeavor to impress upon you the importance of roads in our social, economic and material life, the arteries through which our very life blood flows, but it is not necessary in this gathering nor in the hearing of these men who have and who play so important and responsible a part in the road game of Wisconsin.

I must be permitted to digress, however, to pay my passing respects to the wisdom that enacted the primeval law in Wisconsin requiring that responsibility must rest upon some unit, though it was placed upon the towns, for in our experience in other states and sections we were led to believe that roads were not required by law and that there was no responsibility for any sort of maintenance of them.

I must digress further to question, without paying any passing respect to the wisdom of the acts of recent legislatures in our state, which apparently have not been imbued with or in possession of capacity to appreciate the importance of highway legislation. I do not know whether to charge this lack of measuring up to the stature of legislators upon the political bunk that oftentimes becomes intermixed and prevalent in legislative bodies, or whether it was due to an impregnation of expediency coupled to lack of mental capacity and qualifications, but in the defeat of the Hirst bill in the recent legislature there has arisen in the minds of a very vast number of people in Wisconsin a grave doubt as to the wisdom, capacity and foresight of the legislature. We missed a step in the forward movement, but with hope and courage we look forward to the future and the assistance and encouragement of wise and necessary legislation.

In this connection, permit me to make an observation that is oftentimes forcibly brought to the mind of the county, town and state officials, and that is the limits imposed by law upon officials in he performance of the functions and duties of their office, and the units deriving their powers from legislative enactments might and should, with wisdom and without danger and with decidedly great advantage in many instances be entrusted with greater flexibility and elasticity in the authority and powers required and exercised in the performance of their duties. Without going into details, and paraphrasing an old and trite phrase, "What in hell is the constitution between friends," so might we exclaim what is the necessity or wisdom of placing legal curtailments upon progress in road building, when the legislative authority appears to have no interest in financing the projects. There is apparently a sort of jealousy upon the part of the legislature over county boards and highway organizations and the restrictions as to the exercise of their functions are too great in view of the part the state takes in providing funds. A larger and more liberal viewpoint upon the part of the legislature should take the place of the present narrow views of our legislators.

There should be no limit to the law in the matter of building roads, and the people should decide what they want so long as the public pays the bills and provides not only the finances but the effort and energy to carry out the program.

The great essential in a county organization should be enthusiasm, in other words, "pep," coupled with sufficient well-directed brain matter. The next essential is to have foresight, with a well-defined program and an object in view. The county organization should

possess vision, a vision that takes into consideration the present needs of the communities and the future. The county organization should be dreamers as well as practical men of affairs—for the road of today leads to the road of tomorrow, and foresight is a mental capacity of great and enduring value in any man or organization of men. The organization should first of all feel the responsibility that lies upon them and possess enthusiasm and courage to carry forward. Lacking these, the organization is not only handicapped, but are out of place in the road game. The officer who does not feel the pressing of obligations upon his mind and shoulders cannot function properly, and he is a misfit and a hindrance. Responsibility and enthusiasm carry with them a keen appreciation of the work in hand and the possibilities of the job. They are the supreme essentials in any work, and this game no accomplishments can be achieved without them.

While we must admit that the dear public receives from its servants and slaves a great deal more service than it pays for, this lack of public appreciation and compensation should not deter any real road man from "bucking the game" to the limit. My long experience in county affairs has taught me the fact that the average, the large average, public official is a real philanthropist with his time and efforts for the public good and advantage, and we may wonder at what has been accomplished in Wisconsin in the past few years in view of the compensation received by the officers who are charged with the work and responsibility.

Getting down to details, the county organization should first of all provide a working force consisting of sufficient men, with a highway commissioner at the head, qualified by brains and energy to carry out the program of construction and maintenance. The county committee, whether elected or appointed, should be selected for their fitness for and interest in their office. With the administration placed in such hands, the work of the department will proceed properly. The committee should provide the highway commissoner with such assistants as the work requires, and not as is dictated by a false economy or a fear of the expense. These employees should be paid a compensation that will enable them to devote their entire time to the department, and they should not be compelled to eke out an existence during a part of the year at other jobs. Do not make a mistake in placing the scale of wages at a rate that will discourage or drive men out of the work.

Efficiency commands a price and a county as well as all other organizations must have that in order not only to secure results, but to justify itself to the public.

The highway commissioner should have a least one assistant upon whom he can place the burden of some of the detail work of the department, both in supervision of construction and maintenance, and this assistant should be capable of relieving the commissioner of any part of the work at any time.

With capable foremen, who are experienced and faithful in their work, there should be a constant building up of the working force by continuous employment of men who show an interest in their work and perform it without the supervision of their superiors. A county organization should strive to keep the working intact from year to year so far as possible. Good men should be rewarded, and incompetents discharged without ceremony. The department should be organized for service, pure and simple, and no other consideration should be allowed to enter into the organization or its forces.

The county committee and highway commissioner should make plans in advance, and these plans should be made with a keen foresight. It is not enough that work be laid out for a year. We should have plans projected, so that we will know where we go from here. The plans or program should be constructive in the fullest meaning of the term. As stated in the title, we exist to give transportation service, and the organization should strive to arrange their program and plans, as well as practice, to serve the highway traffic. This service should be continuous, intensive and emphatic. I repeat that plans for the present should be made with an eye to the future, and an organization is not functioning properly unless it keeps at least two jumps ahead of the public demands. There should be an objective, definite and conclusive so far as possible, projected so as to provide service for the greatest extent of the community in the least possible time consistent with the machinery and funds provided for the purpose.

Permit me to advise that in laying out the program or projects the needs of the community should first be considered. We are the servants of the unit, and so far as is consistent with good practice the unit should be given first thought and first consideration in preparing plans. I must say frankly that I cannot get very enthusiastic over the tourist nor the man in the limousine. My bowels of sympathy are moved primarily by the needs of the community and its commerce, and I cannot get up as much interest in a supercilious occupant of a touring car as I can in Bill Jones hauling a load of hogs to market or the farmer speeding to town in his flivver with the family bent upon buying something in our stores or attending the movies. We are the servants of the common people, the taxpayers of the government, and the flitting passerby cannot arouse my ire by criticising our program of road construction. I care not one whoop for the criticism of anyone but the men who pay the bills.

The county organization must also justify itself in the service rendered by not only the construction program, but what is of greater importance, that of intensive maintenance. There can be no excuse for neg-

(Continued on page 256)

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

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Copy for classified and other advertisements where proofs are not required will be accepted until noon on Monday of the week of issue.

Articles by road builders are solicited. They should be short and, if possible, accompanied by photographs. Those accepted will be paid for at current rates.

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MOTOR TRUCK OVERLOADING

Many states are giving considerable attention to the overloading of motor trucks and as a result many laws are being passed which attempt to overcome this evil. During the recent session of the New York Legislature a law was passed which contains drastic provisions against the abuse of highways in that state. Loads are limited to 28,000 lb. and the allowable weight on one wheel fixed to 9,800 lb., with a maximum load per inch tire width at 700 lb. The use of rubber tires worn to less than 1 in. above the metal flange is prohibited. For the first time the speed of trucks operating in the state is regulated. Motor trucks not exceeding two tons capacity are limited to a speed of 20 mi. an hour and trucks of greater capacity than two tons are limited to 15 mi. an hour. Trucks equipped with pneumatic tires are allowed an additional 5 mi. in excess of the above speeds. Excess loads found by inspectors will be unloaded on the roadside.

That New York intends to enforce this law is seen by the fact that recently fines of $25 each were imposed upon 150 motor truck drivers in one day. Since all fines collected under the law will revert to the highway funds of the towns in which the arrests are made, it is probable that local authorities will lend their utmost cooperation to the enforcement of the law.

For the first offense of overloading a fine of $50 or month in jail may be imposed, for the second offense a minimum fine of $50 or two months in jail is provided, while for the third offense the minimum fine that can be imposed is $100 and the registration of the motor truck will be suspended not less than thirty days nor more than six months.

HIGHWAY DRAINAGE

Much has been said and written on the importance of proper drainage to the life of a road, yet it is doubtful that this subject can be overemphasized. Elsewhere in this issue an article by C. M. Upham, State Highway Engineer of North Carolina, who states that "no distinct advantage can be claimed for the tile drain above the open ditch; nor can it be said that the open ditch is more favorable at all times than the tile drain. But there are certain conditions where a combination of the two will be the most practical. If an open ditch is used there is no advantage in making it any deeper than to intercept water, and it should not be so deep that it cannot be maintained by machine; otherwise the maintenance will be a costly item. An open ditch can be used to intercept water as efficiently as a tile drain. The open ditch must be constantly maintained and presents a hazard to traffic. On the other hand, a tile drain will serve as well as an open ditch when used to intercept water from getting under the roadway. The maintenance of a tile drain is generally less than the open ditch, although many times its original cost of construction is greater. At no time does the tile drain present any hazard to traffic, and for this reason it should be given serious consideration."

AMERICAN ROAD BUILDERS' ASSOCIATION ANNUAL MEETING

The annual meeting of the American Road Builders' Association will be held on May 15 at the Automobile Club of America, 247 W. 54th street, New York City. Previously, the annual meeting was held in November, but the date has been advanced to May so as to enable officers elected to have more time in making plans for the annual convention and good roads show.

In the morning the directors will meet. In the afternoon at 3 o'clock the annual general meeting of the members will be held, at which the officers will render their reports. At 6:30 p. m. the annual "get-together" dinner will be held in the grill room of the club, following which the tellers will announce the officers elected for the ensuing year. The retiring and the new presidents will make addresses.

New Orleans, La., will be able to carry out its 1922 paving program in full. The fire, police, and health departments, in response to an appeal from the Finance Commissioner, have given over $140,000 from the funds which had been apportioned to them in the 1922 budget.

NECESSITY FOR STRONG COUNTY ORGANIZATIONS

(Continued from Page 254)

lecting any part of this work, and no excuse should be accepted by the administrative authority for the lack of attention to this work upon the part of any employee. The county should provide for and maintain sufficient patrolmen to properly attend to this work, and pay them wages sufficient to permit them to remain in the service. Niggardly economy or restrictions as to the time and compensation for this service should be absolutely eliminated, and the county organization should be not only broad-minded, but insistent upon the performance of maintenance work. Broadminded, I mean in the sense of being liberal in paying wages, and rewarding the faithful and discharging the incompetent. The public views this service as the most important in connection with highway administration, and the county organization must meet the demands of the public, and strive diligently to render to the greatest possible extent the maintenance that the public demands and has a right to on our highways. The wisdom of the Highway Commission in emphasizing this important branch of highway work has brought forth results that are not only reflecting glory upon Wisconsin, but what is more important, the satisfaction and approval of the public.

The committee must give attention to their duties, and not neglect their responsibilities by the thought that it is costing a county a few dollars every time they meet. The law has imposed obligations and responsibilities upon the county committee, and none of these can be overlooked or neglected without impairment of the service. Ordinarily the average county committees of the county boards have been sort of afraid of meeting, for fear the board might criticise or view with suspicion their per diem accounts. The present statutory committee cannot function properly if it has that in mind.

The essentials of a county organization must be a capable highway commissioner backed by a county committee with a keen sense of responsibility and enthusiasm. The committee must have the road program in mind and must plan with discernment and foresight. The committee should provide the highway commissioner with sufficient and capable foremen, and pay these men good wages, ample to permit them to live upon their earninigs and to remain year after year in the county's employ. Do not make the mistake of cutting wages too low. Efficiency commands a price, and a county must have that if it is to secure results for the money expended in road building.

The highway commissioner should have at least one assistant upon whom he can depend under all circumstances. In our county we have one assistant, who also acts as superintendent of maintenance. The highway commisioner should have someone who can relieve him of some of the detail work and supervision, and the committee can arrange this assistant's duties so that he can not only relieve the commissioner, but be of valued assistance in the general work of the department and a saving to the county in many ways.

Our county's plan is:

Five members of the committee, appointed by the chairman of the county board.

A committee clerk, who attends to the accounting work of the department.

The committee meets frequently, at least once each month. Frequent inspections of the county roads and bridges are made and work in hand and projects for the future are inspected and taken under advisement. We aim to keep a careful oversight of work, and to protect the public from bridges that may become inadequate to carry the increasing tonnage.

We initiate projects and consult with town boards wiith reference to roads and bridges and suggest changes and relocations that will be of public benefit.

We advise town boards as to advisabilty of granting petitions for alterations in or laying out of highways and volunteer our assistance in road matters and securing right of ways in such cases, enabling the towns to purchase releases at a saving of money in many instances.

We prepare a budget for the annual meeting of the county board and outline the work for the ensuing year. We also make a printed report to the board each year, and include the highway commissioner's report in the book. The report may not be important, but we find that the publicity that it gives and the attention that it attracts from the public demonstrates that it is well worth while and interesting. We print 500 copies each year and these are in great demand and the supply is generally exhausted during the year.

The budget includes the appropriations asked for by the towns, which we approve or disapprove before they are included in our estimates, and we find that our recommendations are invariably adopted and approved by the county board, as they realize that the committee is in a position to advise whether or not the appropriation can be spent to good advantage and for the public good of the town and county. Our budget is carefully considered and generally checked over before being presented, and we always get the money.

We believe in the widest publicity and we have created an interest in our work by telling the people through the newspapers and in our reports what we have done, what we are doing and what we propose to do, and we invite their constructive criticism. The result is that we have behind us a strong public sentiment in favor of and approval of our road program, and the construction and improvement of our roads goes foward with liberal appropriations by the county board and the confidence and commendation of the taxpayers.

Developments in Methods of Constructing Brick Pavements*

By ARTHUR H. BLANCHARD†

During the past decade, the brick pavement has had an unusual history of development. Paving brick have been manufactured in a great variety of sizes and types. Changes in methods of construction have been many and varied, some of which have been very unsatisfactory. Notwithstanding these conditions, the properly constructed brick pavement has remained a generally accepted type for use on state and county trunk highways, subjected to intensive and heavy traffic, and for use on many classes of streets in municipalities.

The time is opportune to analyze the present status of paving brick and brick pavements, especially from the standpoint of types of paving brick and also because that leader of practice for many communities, the National Paving Brick Manufacturers' Association, recently has given material aid in the simplification of the paving brick situation and is now advocating the general utilization of an efficient method of construction.

In this discussion of brick pavements, only two important characteristics of an ideal pavement will be considered. It is generally acknowledged what satisfactory pavements must be durable and waterproof. A brief analysis of the several types of brick pavements will be considered from the standpoint of these two essential characteristics.

In the early days of brick pavement construction, a sand foundation and sand filler were employed. This foundation proved inadequate for even medium traffic while the joints, being filled with sand, allowed water to pass through them to the sand bed below. A movement of the sand in the joints and bed naturally followed with the resulting displacement of the brick under traffic.

The first noteworthy development was the utilization of the cement concrete foundation, sand cushion and bituminous cement with which to fill the joints. These improvements indicated the application of sound engineering principles to the design of brick pavements. It was soon recognized that one essential feature of this method of construction was to utilize a bituminous cement which would adhere to the brick and would not be susceptible to changes in temperature to such an extent as to make it unsuitable for use as a filler. Unfortunately, some of the bituminous cement fillers employed had a tendency to chip or become brittle in cold weather and flow in warm weather. The results were unfortunate as the joints did not remain filled with bituminous cement and the exposed edges of the brick were chipped or broken off by the impact of iron tired wheels or horses' hoofs. Fortunately, however, many brick pavements were laid with joints filled with asphalt cement having the proper physical and chemical properties, including a minimum susceptibility to changes in temperature. In 1911 and 1912, the writer had the opportunity to inspect many sections of brick pavement, with asphalt filled joints, in municipalities in Indiana, Michigan, and Wisconsin. These pavements had joints filled practically flush with the surface of the pavement although they had been subjected to traffic for from five to ten years. The pavements possessed the desirable durability, while the surfaces were waterproof. This type of construction has continued to be used by engineers who are familiar with the best methods of constructing pavements.

The next development was fathered by the National Paving Brick Manufacturers' Association. It consisted in the substitution of cement grout filler for the bituminous cement filler. After several years use of this method of construction, it was finally conceded that it was very difficult to secure uniformly filled joints by using cement grout and that a monolithic brick slab cracked, due to temperature stresses, thus enabling water from the surface of the pavement to reach the sand cushion, which gradually became displaced. It also became evident that the action of traffic on the weak sections of the pavement surface and on portions of the brick wearing course over the areas of displaced sand cushion caused many failures of brick pavements. These failures were due primarily to contraction stresses. Failures, however, occurred due to expansion stresses, such as the "blowing up" of sections of brick pavements.

The next developments were also introduced by the National Paving Brick Manufacturers' Association, one of the new methods consisting in laying the brick on a cement mortar bed resting on a cement concrete foundation and the other, laying the brick on green concrete. The joints in both methods were filled with cement grout. These methods are not at present promoted by the Association.

West of the Mississippi, the Western Paving Brick Manufacturers' Association has exerted considerable influence. This Association advocates the use of what is called vertical fibre brick with the rough surfaces uppermost and recommends that the surface be covered with a squeegeed coat of asphalt and the joints filled with asphalt cement.

At the last meeting of the National Paving Brick Manufacturers' Association, held on December 7, 1921,

*Paper presented at Eighth Annual Conference on Highway Engineering at the University of Michigan.

†Professor of Highway Engineering and Highway Transport, University of Michigan.

the Association expressed "its confidence in asphalt filled brick wearing surface for street and highway paving properly designed and built with acceptable materials and thorough methods," and the Association further declared "its preference for the asphalt filled types of wearing surface" with the proviso that "preferment of the foregoing type of brick wearing surface for general use shall be without prejudice to any other type which may possess peculiar adaptation to special local conditions." In view of the fact that the Association has exerted a powerful influence over the practice of the construction of brick pavements in many sections of the country, it is hoped that, as a result of its latest recommendation, the durability of future construction in all sections of the country will not be jeopardized by the use of cement grout as a filler but that bituminous cements, possessing the desired characteristics, will be universally employed.

In order to insure the use of a bituminous cement possessing the desirable practical minimum susceptibility to changes in temperature, the writer, in his private practice in northern states, has recommended, among other requirements, the following clauses covering the penetration of asphalt cement fillers:

Penetration at 25°C. (77°F.), 100 grams, 5 sec., 30 to 40.

Penetration at 4° C. (39° F.), 200 grams, 1 min., not less than 15.

Penetration at 46° C. (115° F.), 50 grams, 5 sec., not more than 85.

In order that the asphalt cement may be economically used to fill the joints, the writer advocates the use of conical pouring cans. The practice of squeegeeing asphalt cement over the surface of a new lug brick pavement is uneconomical, as a thin surface of asphalt is not an essential part of a properly constructed brick pavement. Whereas it may be practicable to secure good adhesion between asphalt cement and the rough surface of the wire cut sides of paving brick, the experience of the writer indicates that asphalt cement applied to the glazed surface of paving brick will usually peel off after being subjected to intensive and heavy traffic.

The present types of paving brick manufactured require careful consideration from the standpoint of the efficient construction of durable and waterproof brick pavements.

A notable economic development resulted from the action of the Secretary of Commerce of the United States, Hon. Herbert C. Hoover, in calling a Conference on the "Simplification of Variety and Standards for Vitrified Paving Brick" in Washington on November 15, 1921. This conference recommended the elimination of 55 out of 66 varieties of paving brick used in the United States. The 11 varieties which were retained include two sizes of plain wire-cut brick, two varieties of repressed lug brick, two varieties of vertical fibre lug brick, three varieties of wire-cut lug brick, and two varieties of hillside lug brick.

Leaving out of consideration hillside lug brick, highway departments east of the Mississippi River are primarily interested in the three types, plain wire-cut brick, repressed lug brick, and wire-cut lug brick. The two types of lug brick have been in successful use for many years and their inherent merits are well established. Many highway departments allow the use of either of these types under their specifications. It is well known that the utilization of lugs on the sides of these two types of brick is for the purpose of uniformly spacing in the laying of the brick in pavements and the providing of joints which can be filled satisfactorily.

In 1919, some of the manufacturers of vitrified paving brick began to manufacture a plain wire-cut brick. As a result of the United States Department of Commerce Conference, two sizes of this type of brick will be manufactured, namely, 3x4x8½ in. and 3½x4x8½ in. As these brick do not have lugs, it is apparent that two requirements relative to depth may be satisfied with one size of brick. For example, the 3x4x8½ in. may be used by highway departments which wish to lay brick with a four inch depth and also by those departments which wish to use a three inch depth.

Since the introduction of this type of brick, the writer has endeavored to determine its merits and the economy of its use. It is apparent that the following question would naturally arise. Will it be practicable to space the brick during construction so as to provide uniform and satisfactory joints? It was soon evident that the proper construction of a pavement surface of lugless brick would depend upon the ability of the pavers to satisfactorily and uniformly space the brick. Reports from contractors indicate that considerable difficulty was encountered even leading to the use of artificial means, such as the employment of an angle iron, to secure the desired joints in the brick surface.

Information relative to the results secured was so unsatisfactory that the writer decided to construct an experimental pavement in the laboratories of the Division of Highway Engineering and Highway Transport at the University of Michigan. The writer wishes to acknowledge his indebtedness to Professor John H. Bateman, Director, Michigan State Highway Laboratory, laboratory assistants and two engineers of the Ohio Paving Brick Manufacturers' Association for their kind cooperation in the construction of the test pavement.

The experimental pavement was constructed within a wooden frame, 2 ft. 6 in. in width and 8 ft. in length, which rested on a cement concrete floor. A sand bed, 1 in. in thickness was prepared upon which 3½x4x8¾ in. plain wire-cut brick, furnished by the Metropolitan Paving Brick Company, were laid by one of the engineers of the Ohio Paving Brick Manufact-

urers' Association. The section was laid to conform with average practice on contract work. A Texaco asphalt cement filler, having a normal penetration of 33, was heated to 350° F. It was poured by one engineer and squeegeed by another engineer of the Ohio Paving Brick Manufacturers' Association in accordance with the standard specifications recommended by the National Paving Brick Manufacturers' Association.

On several rows of brick, complete measurements covering the widths of all end and side joints were taken before the application of the filler. The measurements, expressed in inches, of the end joints of a part of a typical row follow: 1-16, 1-64, 1-8, 1-4, 1-8, 1-16, 1-64, 1-16, 1-64. The joints on one side of this row measured as follows, there being two measurements to each brick due to the fact that the bricks were laid to break joints in adjacent rows: 1-8, 1-4, 1-16, 1-16, 1-4, 3-16, 1-8, 1-8, 1-16, 1-8, 5-16, 3-16, 1-8, 1-32. The measurements on the other side of this row of brick were as follows: 1-8, 1-32, 1-16, 1-8, 1-64, 1-64, 1-64, 1-8, 3-16, 3-16, 1-4, 3-16.

With the approval of the engineers representing the Ohio Paving Brick Manufacturers' Association, the pavement was taken apart four days after it was laid. The depth of penetration of the asphalt cement on the sides of the brick was found to vary from 0.1 to 3.5 in., the full depth of brick. The average depths of penetration on three sets of six consecutive bricks were 0.7, 1.2 and 1.6 in.

The results obtained in the construction of the test pavement conform with the results which one might expect from the use of plain brick without some artificial means of securing suitable open joints. Even if some method, such as the use of an angle iron, was employed to secure uniformly spaced plain wire-cut brick, there is no guarantee that the brick would not be displaced during rolling prior to the application of the asphalt filler.

Considering the established fact that successful asphalt filled brick pavements may be constructed with repressed and wire-cut lug brick and that the use of plain wire-cut brick is accompanied with great risk relative to securing well filled joints, the writer is of the opinion that conservative practice dictates that only lug brick should be employed. From the standpoint of the economics of construction, the use of the plain wire-cut brick is not justified. There is no indication at present that there is any material difference in the price per thousand of the lugless brick and the lug brick. Furthermore, granted an increase in cost of lug brick over lugless brick, the excess cost of lug brick is a good investment from the standpoint of insuring the construction of a durable pavement with the joints properly filled with asphalt cement.

Union County, New Jersey, recently adopted a paving program involving the estimated expenditure of $753,000 for new roads and resurfacing.

BITUMINOUS TREATMENTS FOR EARTH AND GRAVEL SURFACES

In the consideration of the problem of how to preserve and derive the maximum service from its top soil, sand-clay and gravel roads, the State of North Carolina has something in common with many other states, having large mileages of these type of roads which now demand some form of treatment to protect them from the disintegrating effects of modern traffic.

The North Carolina State Highway Department has found that a bituminous material light enough to penetrate the sand-clay, top soil or gravel surface does not have binding quality, and on the other hand it was developed that a material which did have sufficient binding quality was too heavy to penetrate the road. In the case of the heavy treatment, the bituminous material went into the formation of a mat on the surface of the road, and the bond between the road and the bituminous mat was eventually destroyed by the dusting up of the surface beneath the mat. The weakness in this treatment was not in the bituminous blanket but in the contact between the bituminous blanket and the road surface.

The sand-clay, top soil or gravel surface is first softened by sprinkling, and then a single layer of broken stone or gravel of approximately 1.5 in. in size is rolled inot the surface. After giving the surface time to dry out, and in order to secure maximum consolidation, the roadway is opened to traffic for a short period, after which it is swept clean by brooming.

The road then presents an ideal surface for treatment with an asphaltic material, one to which a material possessing the desirable binding qualities may be applied without danger of being separated from the road surface by the dusting up of the surface as a result of the impact of traffic.

The North Carolina State Highway Department has used Texaco No. 55 road oil in its experiments, and while the new construction has not been subjected to traffic long enough to say that it has proven absolutely satisfactory, it is anticipated that the result of the experiment will be to produce a waterproof, durable and resilient mat which will add considerably to the efficiency and life of sand-clay, top soil and gravel roads.

LOWER COST OF ROAD CONSTRUCTION

Confirmation of the predicted lower level of prices for road construction this year is found in the reports on bid prices of 286 mi. of federal aid roads received by the Bureau of Public Roads during the week ending April 8.

The average cost per mile of some of the types of roadway, including the cost of grading and drainage, were: 78 mi. of gravel at $9,150 a mile, 46 mi. of concrete at $29,000 a mile, 47 mi. of bituminous macadam at $25,000 a mile, and 23 mi. of bituminous concrete at $25,000 a mile.

MEETINGS

Calendar of Coming Meetings

May 12—National Highway Traffic Association—Annual meeting, Automobile Club of America, New York City. Secretary, Elmer Thompson, 247 West 54th St., New York City.

May 26-27 — Dixie Highway Association — Annual convention, Jacksonville, Fla. Secretary, M. B. Roberts, 302 First National Bank Bldg., Chattanooga, Tenn.

June 4-6—American Association of Engineers—Annual convention, Salt Lake City, Utah. Secretary, C. E. Drayer, Chicago, Ill.

June 13-16—Canadian Good Roads Association—Ninth annual convention, Victoria, B. C. Secretary-treasurer, George A. McNamee, Birks Bldg., Montreal, Canada.

June 26-July 1—American Society for Testing Materials—Twenty-fifth annual meeting, Atlantic City, N. J. Secretary, C. L. Warwick, Engineers' Club Bldg., Philadelphia, Pa.

Aug. 9-10—Custer Battlefield Highway Association—Annual meeting, Sheridan, Wyo. Secretary, W. D. Fisher, Sheridan, Wyo.

Oct. 9-13—American Society for Municipal Improvements—Annual convention, Cleveland, O. Secretary, Charles Carroll Brown, St. Petersburg, Fla.

CONFERENCE ON TRAFFIC SIGNAL COLORS

The American Engineering Standards Committee has called a conference to be held May 23 at the rooms of the committee in the Engineering Societies Building, 29 West 39th street, New York City, to determine whether a standardizaion of the colors used for traffic signals should be undertaken.

This conference has been called in accordance with requests received from the Illuminating Engineering Society and from the International Traffic Officers' Association. These organizations have called attention to the fact that there are being placed on the market and in use, semaphore control apparatus having numerous colored lights at variance with each other and at variance with colored lights used for other purposes along the highways, thus leading to confusion and to numerous accidents. In their opinion there is need of a thorough study of colors for traffic signals in order that there may be national uniformity in the use of colored lights for such purposes. Consideration will be given to the use of colored signal lights on automobiles, bicycles, tractors, trailers and horse-drawn vehices; to their use on semaphores and other position signals along highways and at curbs; to methods of specifying or defining colors for such uses; and to the relation of such lights to railway signals, to temporary danger signals placed along highways, and to fire exit signals.

The status of the subject and the facts bearing on it as they exist in the automobile, steam railway, electric railway and regulatory commission fields will be outlined in a few brief papers in order to lay a proper foundation for the discussion of the necessity for and feasibility of developing standard colors for traffic signals.

WAR MATERIAL FOR ROAD CONSTRTCTION

A force of about 275 persons is kept in the field by the Bureau of Public Roads to inventory and prepare for shipment to the various states the vast supply of surplus war material which is suitable for highway construction. The material is allotted to the states on the same basis as the monetary federal aid for road construction. Every effort is being exerted to make this material available early this season. Surplus war materials recently received for distribution and located at Schenectady, N. Y.; Watertown, Mass.; and Dover, N. J., include 200 carloads of brick, about half of which is suitable for highway paving; 5,000,000 lb. of nails, 1,000,000 lb. of staples, 1,000,000 sq. ft. of concrete reinforcing mesh, 200,000 monkey wrenches and 133 carloads of picks and pick handles.

REPAIR ROAD WITH VOLUNTEER LABOR

According to the Secretary of the Chamber of Commerce of Canon City, Colo., the Phantom Canon Highway has been reconditioned by volunteer labor. The road, which was rendered impassable by floods, covers 32 mi. from Canon City and Florence to Victor and Cripple Creek. The state and county highway appropriations could not take care of the expenditures necessary to restore it to normal condition and the citizens of the localities through which the road passes decided to take the matter into their own hands. With from 75 to 150 men working each day, two weeks' time saw the road again open for travel.

EXAMINATIONS FOR TRANSITMAN

The United States Civil Service Commission will hold an examinaiton on May 10 for transitman in the General Land Office Service, $120 to $150 per month and subsistence while in the field. Application should be made to United States Civil Service Commission, Washington, D. C., or to any local office of the commission.

A recent change in the laws of Virginia provides that the entire proceeds of the automobile tax after Dec. 31, 1922, shall revert to the maintenance of the state highways. At the present time, one-third of the tax is available for construction. Motor vehicle fees in Virginia amount to approximately $2,000,000 annually.

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Vol. LXII May 10, 1922 Number 19

TABLE OF CONTENTS

*The Missouri River Bridge in North Dakota. By W. H. Davidson 261
*Types of Traffic on Connecticut Highways . . . 265
*Federal Aid Status 268
To Build Montana Forest Roads 268
Road Material Surveys Lessen Costs 271
South Carolina Numbers Highways 271
Road Building Costs in Wisconsin 271
The Outdoor League of America 271
Status of Federal Aid in Montana 271
Brick Highway for Indiana 271
Federal Aid Road Construction 271

EDITORIALS:

Segregation of Motor Trucks 269
Highway Legislation in Congress 269
Influence of Federal Aid 269

EQUIPMENT-TRADE-MATERIALS:

*Paver Equipped with Rubber Tires 270
Diesel Engine to Operate New Shovel 270
Caterpillar Traction for Shovels 270
Built to Endure 270
*The New Sterling Convertible Level 270

MEETINGS:

Calendar 272
Program for A. S. T. M. 272
Conference on State Parks 272
National Chamber of Commerce to Discuss Highway Transport 272

*Illustrated article

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The Missouri River Bridge in North Dakota*

Many Interesting Engineering Problems Encountered in Construction of Sub-Structure—Total Cost of Structure Will Amount to Approximately $1,325,000

By W. H. ROBINSON†

Just when the Missouri River Bridge had its beginning is very difficult to determine. Some philosophers tell us that all things have their beginning in the world of thought, which they consider to be the only true world and that the material world is simply an imitation or reflection of that true world. Be that as it may, the people of Bismarck and Mandan and other localities who have frequently had to cross the Missouri River by means of a ferry or who are unable to cross it at certain periods of the year decided that a bridge existing only in the minds of men was not adequate for their purposes and therefore at different times during the past have attempted to materialize such a structure.

The first record we have of these attempts is one some six or eight years ago, when the state engineer was called upon to prepare preliminary plans and make an estimate of the cost. This attempt was not immediately successful. Along about 1918 a successful effort was made to secure authorization from Congress for the construction of such a bridge. This authorization was given on Feb. 27, 1919. About the same time a bill was passed by the North Dakota Legislature which appeared to authorize state aid in the amount of one-third to bridges located on the state line or over a navigable stream. The legislature, however, failed to provide a fund that could be legally drawn upon for that purpose until the special session of 1919, when an appropriation of $225,000 was made. The session of 1921 made an additional appropriation of $175,000, making available a total of $400,000 to meet the state's share of the cost. This did not prevent preliminary action on the proposed bridge. Early in April, 1919, negotiations were begun between the Counties of Burleigh and Morton.

On May 3, 1919, the Burleigh County commissioners passed a resolution appropriating $90,000 to become available at the rate of $30,000 per year for the years beginning July 1, 1919, 1920 and 1921. On May 6 of the same year Morton County made a similar appropriation. Later, these appropriations were increased to $131,000 by each county.

*Paper presented before American Association of Engineers.

†Chief Engineer and Secretary, North Dakota State Highway Commission.

VIEW OF PIER NO. 2

PIER NO. 1 UNDER CONSTRUCTION

On May 19 of the same year bids for preliminary engineering were received at Mandan. Six or seven bids were received, which included proposals from some of the best known engineering firms in the country. The purpose of this preliminary engineering was to make test borings over the proposed site or sites and furnish preliminary plans that would be satisfactory to the State Highway Commission and the Bureau of Public Roads. The C. A. P. Turner Company, of Minneapolis, was selected by the county boards, the highway commission having submitted design specifications for the structure and having intimated that it would accept the plans of the engineer selected if same were satisfactory to the Bureau of Public Roads, which was expected to furnish half of the funds.

The general plans were submitted to the highway commission during November of that year and were approved on December 29. In the meantime plans had also been submitted to the War Department for their approval. The War Department formerly had required a clearance of 50 ft. above the highest water level of the navigation season. It was believed by many that this clearance was far greater than the present or prospective navigation needs demanded and a movement was begun in 1919 endeavoring to have this clearance requirement reduced. A hearing was held at Kansas City during the fall of that year and on Jan. 8, 1920, the War Department approved the proposed plans showing a clearance of 38 ft., which gives a clearance of approximately 55 ft. at normal low water or a roadway height of 60 ft. above normal low water. This reduction in height of 12 ft. has undoubtedly decreased the necessary length of the approaches several hundred feet and for this and other obvious reasons the cost has also been greatly reduced.

The design specifications of the State Highway Commission submitted and approved by the Bureau of Public Roads required that the structure should be designed for a uniform live load of not less than 60 lb. per square foot for spans over 200 ft. in length and a concentrated live load of four typical trucks each weighing 25 tons. Seventeen tons of these loads were assumed to be on the rear axle and eight tons on the front axle. The axles were assumed to be 10 ft. apart. The width of the wheels were assumed to be 6 ft. between center and the space occupied by each truck was assumed to be 20 ft. long by 9 ft. wide.

Provision was also made for an additional impact load of 30% of the live loads in the calculation of floor members and all truss members taking direct floor loads. An impact load of 20% on the live load was calculated for all other members. Besides these, of course, the usual provision was made for wind pressures and dead loads.

Later, an additional requirement was made that provision should be made for a railway or interurban track across the structure and that the design should provide for two 50 ton street cars.

The plan adopted consisted of three through truss spans 476 ft. between center of shoes. The trusses are of a type known as the Warren-Turner type. These spans are supported by two main river piers and two main shore piers located 481 ft. center to center constructed of reinforced concrete.

The shore piers consist of two cylinders with bases 20 ft. in diameter and 10 ft. in height. From this point to slightly above low water level the piers are continued as cylinders 14 ft. in diameter. Above this point they are reduced to cylinders 9 ft. in diameter, these being connected at their base by a girder 9 ft. in thickness and 12 ft. in height, and also connected near their tops by an arched web. The base of the eastern shore pier is located about 43 ft. below normal low water and about 103 ft. below the roadway. The base of the western shore pier is located about 75 ft. below normal low water and 135 ft. below the roadway. The main river piers have rectangular bases 23x60 ft. and 14 ft. 6 in. in height. Above this point to about 6 ft. above low water the pier is somewhat the shape of a flatiron, the general dimensions being 16 ft. in width by 60 ft. in length. Above this point the thickness of the structure is reduced to 12 ft. The point or up-stream edge is gradually battered or sloped to provide an ice cutter or breaker. This section of the pier is 18 ft. in height. From this point the structure is continued as two cylinders 10 ft. in diameter, which in turn are connected at the tops by an arched web.

The base of the eastern river pier is about 41 ft. below normal water level and 101 ft. below the roadway. The base of the western river pier is approximately 74 ft. below low water level and 134 ft. below the roadway.

The piers were designed to be sunk by the open dredging method. This method contemplated that the excavation would be done by means of a clam shell or orange peel bucket operated through shafts left in the piers. A structural steel frame caisson was provided for each of the main river piers 14 ft. 6 in. in height, the bottom portion of which was designed to provide a cutting edge along the lower perimeter of the base. These caissons were constructed so that a working chamber was provided by sloping the inner wall of the caisson inward and upward from the cutting edge, where in the case of the large piers it terminiated in three openings or shafts 9 ft. 4 in. by 8 ft. These caisson frames were erected over the point where they were to be sunk and logged with 2-in. lumber to provide forms for the concrete. In one case it was erected on the ice and sunk to place by a rather novel method, the details of which would probably make this paper entirely too long. As soon as these caissons were filled with concrete they were sunk so that the upper portions were slightly above water level, another section of concrete then being added while another pier was being sunk by dredging through the

openings. The original design anticipated that these piers would be sunk and sealed in the wet—that is, providing the pier did not seal itself by cutting off the flow of water. Divers would be sent down to level off the bottom when the pier had reached the proper depth. A concrete seal would then be placed by means of a tremie. As soon as this seal had sufficiently hardened it was intended that the water would be pumped out and the balance of the center core placed in the dry. The Bureau of Public Roads, however, would not approve this method and insisted that the piers should be seated and sealed in the dry. It was therefore necessary to place additional reinforcing in the shells of the piers to provide for air pressure where the water could not be kept out by other methods. No trouble was encountered in the two easterly piers as stiff clay was encountered in the first case at a depth of about 26 ft. and the cutting edges readily sunk into this and cut off the water so that the caissons were pumped dry and the excavation carried on by hand. The material was very tough and rubbery and the only implement that handled it successfully was the ordinary mattock. The easterly shore pier was sunk into this clay approximately 16 ft. The easterly river pier was sunk into the clay about 10 ft. When the clay stratum was reached with the westerly river pier considerable difficulty was encountered in cutting off the flow of water. This was made more difficult owing to the fact that the base of this pier was undermined by a sudden change of the river channel before it had been sunk deeper than 8 or 10 ft. This caused the base to crack and warp somewhat. This weakening of the base was remedied by casting on an additional three feet or in other words making the base approximately 18 ft. high instead of 14 ft. 6 in. and by adding considerable reinforcing steel. This crack in the concrete allowed a continuous flow of water to enter when an attempt was first made to pump out the pier. Further complications were caused by the occurrence of a thin bed of coal occurring under one side or end of the pier. After several weeks of very slow progress in which considerable blasting was resorted to the cutting edge finally entered the hard stratum of clay sufficiently to cut off the flow of water and the pier was then sunk to an approximate depth of 10 ft. in the clay and sealed in the dry.

At the location of the western shore pier the original boring showed that clay was not reached until an approximate depth of 90 ft. below low water, the overlying material being silt, sand, gravel and boulders. The pier was sunk to an approximate depth of 75 ft. below low water. At this point numerous boulders were encountered and any load that could be placed upon the cylinders failed to drive them further. A diver was then sent down to make an examination of the bottom and determine more fully the condition of the material. It was decided that the material at this point was satisfactory for a seat for the pier. An interesting condition was noticed in that the water encountered at this depth had more pressure behind it than that occasioned by the height of the water in the river, the result being that the water rose approximately two feet higher than the surface of the river at that time.

It was necessary to import several sand-hogs, in this case southern negroes who had been accustomed to working under air pressure. The air locks were then placed on the two cylinders and a pressure applied sufficient to drive out the water. The bottom of the excavation was then leveled up by the sand-hogs, a concrete seal placed and as soon as same was set sufficiently, air pressure was removed and the working chambers and shafts filled with concrete and rubble in the same manner as the other piers were filled.

The same foundation conditions appear to exist under the entire west approach as were encountered in sinking the shore pier. In constructing the pedestal bases for this approach, Wakefield sheet piling was driven and the excavation carried down by means of a clam shell bucket. When the proper depth was reached a sufficient number of piling 70 ft. in length were then driven by means of a 5,000 lb. steam hammer. This piling was cut off just above the ground water level and the concrete pedestals were then poured so that in each case the base was at least one foot below ground water level.

The main bridge is reached by means of two curved reinforced concrete approaches, the east approach being 480 ft. in length and the west one 625 ft., making a total length for the structure of 2,548 ft. or 92 ft. less than half a mile. The original plans for these approaches contemplated the use of the Turner Mushroom system of design, which is a flat slab type and usually can be constructed at a less cost than designs requiring beam or girders. While there is quite a large number of this type of design in use in bridges and bridge approaches, the stresses developed in the various parts of the design are not easily demonstrated mathematically. Due to this and other facts the Bureau of Public Roads refused to approve the design and insisted that a beam and girder type design should be used.

The roadway on the bridge proper is 26.5 ft. between curbs and on the approaches 28 ft. in width. Besides this roadway, two sidewalks about 4 ft. 4 in. in width are provided. The roadway and sidewalks on the steel spans will be of reinforced concrete. The roadway on the entire structure will be surfaced with 1.75 in. of asphalt.

During the early months of 1920 while the design of the approach was under consideration, the highway commission was authorized to advertise for bids on the four main piers. Arrangements were made to receive bids on the four main piers on March 18, 1920, advertisements being placed in two of the largest engineering journals of the country. Only one bid was

received at that time and that was on a cost-plus-sliding-scale proposition. The highway commission did not consider that one bid was sufficient to warrant its letting a contract. Arrangements were again made to receive bids on May 15. The plans for the approaches having been approved by the Bureau of Public Roads in the meantime, bids were received on the entire structure, the proposals providing for bids by both the cost-plus-sliding-fee and lump sum methods on the four main piers and the concrete approaches. Invitations were sent out to about 30 firms requesting them to submit proposals on the work. About a dozen firms responded but no lump sum bids were received on the main piers. Several cost-plus-sliding-fee proposals, however, were submitted. The lowest combination of bids that could be made on the main piers and the concrete approaches was that of the Foundation Company, of New York.

The basic cost of the main piers estimated by the Foundation Company was $256,319. The fee on this cost or basic fee was $39,500, the minimum fee $30,900 and the maximum fee $48,100. The basic cost on the concrete approaches was $280,119, basic fee $47,000, minimum fee $35,600 and maximum fee $56,400.

An explanation of this bid probably is necessary at this time. If the cost of the main piers had been exactly as estimated by the Foundation Company it would have been $256,319 and on this basis they would have received a fee of $39,500. The cost of the piers overran this amount to a considerable extent. Therefore, the Foundation Company participated in this loss until their fee had been reduced to $30,900, or the minimum fee. Had the cost been less than their estimate they would have received half of the saving until the maximum fee of $48,100 had been reached. After that point all the saving would have gone to the state and counties. Unfortunately, in the case of both the main piers and concrete approaches the cost has exceeded the basic cost to such an extent that in each case the Foundation Company will receive a minimum fee or in other words they have lost $20,000 by underestimating the work. Unfortunately the federal government, state and counties have apparently lost in this proposition in an amount considerably greater than $20,000.

The bid of the American Bridge Company for furnishing and erecting the steel spans was $461,491. Based on these figures plus 10% for engineering and contingencies, the expected cost of the structure was placed at $1,192,000 in round numbers. The final cost, unfortunately, as near as it now can be figured, will probably be in round numbers $1,325,000.

It will be noted that the advance in freight rates was the greatest factor in the increased cost of the structure. The next greatest contributing factor to this increased cost was the temporary trestle. This trestle was constructed early in the summer of 1920, shortly after work began. Late in November the ice went out carrying the trestle with it, this being the only fall break-up during 40 years, according to authentic records on file regarding the river. This trestle was again constructed and the piling portion of it was again carried out in the spring. An attempt was made to transfer materials across by ferry and haul other portions from Mandan. This was found to be very unsatisfactory and expensive, so the trestle was again constructed to complete the west approach and the upper portions of the piers.

The plant layout of the Foundation Company on this project was a matter of considerable interest. The power plant consisted of five boilers averaging about 100 h.p. each. These were used to heat the buildings, gravel piles, furnish power for air compressors, mixers, in curing concrete during cold weather, etc. Three compressors were installed in anticipation of use for sinking piers by the pneumatic process. Fortunately this was not necessary except for a few days, as has heretofore been mentioned.

Considerable saving was made by using air dump cars for hauling gravel and sand from the pit located 12 mi. south of Mandan. These were dumped into a pit by air pressure at the plant. The material was removed from this pit to the stock piles by means of a clam shell bucket operated by a Guy derrick and hoisting engine. This same clam shell outfit was also used for transferring materials to the mixing plant which at this point consisted of a one-yard mixer located so that the concrete could be poured directly into buckets carried upon cars. The concrete was distributed from this plant by means of two gasoline driven Plymouth locomotives on a 36-in. gauge track. At each point where concrete was being poured, steam operated derricks were used to handle the concrete buckets as well as forms. An emergency plant of the same capacity was located on the west side of the river but was used mainly when the trestle was out of commission.

Besides the power house and mixing plant, large cement storage buildings, blacksmith shop, carpenter shop, bunk houses, commissary, office, etc., were in use. At times, when it was necessary to carry on operations both night and day, as high as 250 men were employed.

Work was begun on the main piers during July, 1920, and the concrete approaches were completed so far as was possible prior to the completion of the steel superstructure during September, 1921.

The American Bridge Comany commenced operations on the site during July, 1921 and finished the riveting early in 1922.

As soon as the weather became sufficiently warm the Foundation Company began to lay the concrete slab on the roadway and walks of the main spans of the bridge. After this the asphalt surfacing will be placed and the sections of the brick hand rail that have been left off for the convenience of the American

Bridge Company will be completed. It is therefore probable that all the work will be completed by July 1 of this year.

Considering the difficulties and magnitude of the project it can be considered that the rate of progress and quality of workmanship have been very satisfactory.

Early this year we received the astonishing information from a representative of the Bureau of Public Roads at Washingotn, D. C., that we had overlooked about 3.5 mi. of this structure and that provisions would have to be made to complete this, which is the west approach lying between the bridge proper and Mandan, and that no more federal aid payments would be forthcoming until this was done. Some have contended that a concrete causeway should have been provided over this entire distance. However, an investigation on the part of anyone would soon show that such a structure is far beyond the financial ability of the Counties of Burleigh and Morton and the State of North Dakota at this time, as it is believed that such a structure would cost at least a million dollars per mile. The type of construction suggested by the Bureau of Public Roads is an embankment across this low ground averaging in height probably 6 or 7 ft. on the first 2,200 ft. after leaving the concrete structure. From this point to Mandan the ground is considerably higher and would probably require a grade varying in height from present level to 3 or 4 ft. at the lowest points. The further condition was made that this approach must be paved with concrete not less than 8 in. in thickness. Since this ultimatum the highway commission has been busy, assisted by the attorney general, endeavoring to locate some provision in the laws of the state which will permit them to comply with this requirement. It is estimated that this type of construction would probably cost from $175,000 to $200,000, but it is regretted that to date neither the highway commission nor the attorney general has been able to locate an Aladdin's lantern that can be used to conjure up the treasure chest necessary for this type of construction.

Types of Traffic on Connecticut Highways

Digest of the Report of the Bureau of Public Roads on Traffic Censuses Conducted in Connecticut in Cooperation With the State Highway Commission

During August and October, 1921, the Connecticut State Highway Department in cooperation with the Bureau of Public Roads conducted traffic censuses on two of the principal highways of Connecticut. The purposes of the censuses were to determine the economic value of the highway; the classification of vehicular traffic; the gross weight and wheel loads of motor trucks and the extent of overloading; a basis for the distribution of construction and maintenance costs; density of traffic; width of vehicles and the relation of density and width of vehicles to roadway width; the movement of freight by highway; the speed of vehicles and to serve as a basis for a formulation of traffic regulations.

Time and Scope of the Censuses

The first census was taken during the last two weeks of August on the Hartford-Springfield road at the Massachusetts-Connecticut state line. The second census took place during October on the Boston Post Road at the town of Greenwich, Connecticut. Each of the censuses covered a period of 14 days. The daily survey covered ten hours, rotated so as to determine the traffic movement at the earlier and later periods of the day. Two night counts were conducted to form the basis for an estimate of night traffic. Road scales were installed on both roads to weigh the traffic as it passed over the road. At the Greenwich station a 49,000-lb. automatic Fairbanks scale was used in order to delay the traffic as little as possible.

Duing the first census traffic bound south from Springfield, Mass., to Hartford, Conn., was weighed whether empty or loaded. Northbound trucks were stopped but only commodity information was obtained. The density of traffic was such that it was impossible to weigh trucks going in both directions. In the second census the eastbound traffic from New York was weighed and westbound trucks were stopped only for commodity information. The personnel of the survey included eight men to handle both truck and passenger car traffic. During the second census older men were employed and the results, especially the truck information, were more accurately recorded. Traffic was only slightly delayed by the observers and drivers cooperated willingly when they understood the purpose for which the information was asked.

During the first census, the information, including the weight of the truck was obtained in an average of 1 min., 41 sec., the longest time being 2 min., 55 sec., and the shortest 1 min. At different times during the census speed tests were made and one of the results of the survey is the indication that a more accurate index of truck speed can be obtained at a place a few miles from the traffic station where drivers will not suspect that the test is being made.

The cost of the first census was $1,693, of which $977 was for the scale, $170 for the cost of erecting it and the balance for salaries of the observers. The cost of the second census was $3,331, of which $2,700 was

for the scale and the balance for salaries of observers, etc.

Passenger Traffic Analyses

28,011 passenger cars were recorded during the first census and for 14,036 of the cars observed the records were analyzed to determine the average haul, number of passengers, etc. In the second census 38,566 passenger cars were recorded and the records of 5,023 were analyzed.

The number of motorcycles and horse-drawn vehicles was so small in comparison with passenger cars and truck traffic that their numbers are not reported.

All makes of cars and all types including touring cars, roadsters, and other special types were observed during the census.

44,950 passengers were transported in the observed cars, southbound in the first census. An average of 3.2 passengers per car. During the first census of the licenses observed 50.5% of the total were Massachusetts tags; 34.9% were Connecticut; 7.2% were New York, and 7.2% were miscellaneous.

The location of the census station near the Massachusetts-Connecticut State line and the fact that this analysis relates to southbound traffic accounts for the high percentage of Massachusetts cars.

In the second census the average number of passengers per car was found to be 3.314. The analysis of license tags shows Connecticut with 53.1%; New York 37.4%; Massachusetts 3.2%; New Jersey 3.2%. A daily average of 6,739 passenger cars was found for the two censuses while the daily truck average was 792.

The principal movement occurred between seven o'clock in the morning and eight in the evening, the peak load occurring at 5 p. m. The hourly density of truck movement from 8 p. m. to 5 a. m. indicates the night movement of regular truck lines. During this interval, an average of 13 trucks passed over the roads per hour.

In the first census the daily average of passenger car movement for 24 hours was 2,907. The average mileage per car was 70.018 at 3.2 passengers per car, and figuring the value of the passenger service rendered at the railroad rate of 3.6 ct. per mile the passenger service on the Hartford-Springfield road during the two weeks was valued at $327,595.

During the second census the daily average of passenger car movement for 24 hours was 3832.4. The average mileage was 52.4. Computing the value of the service as above the value for the two-week interval was $355,417. On the two roads together the value of the service rendered for a year would be $17,238,326. This figure is merely the value of the service rendered by these two roads estimating the value at railroad rates. It is not the cost of the service rendered by the roads.

Truck Overloading

The truck weight data from both censuses was analyzed to determine the wheel and axle loads and to ascertain what percentage of the vehicles weighed in excess of the legal limitation of 25,000 lb., and what part of the traffic consisted of vehicles with wheel loads greater than 800 lb. per inch of tire width, and what proportion of the vehicles were overloaded when gauged by the capacity rating of the manufacturers. The latter practice is referred to as overloading per capacity. The weight standard used in determining overloads for each make and capacity consists of a summation of the manufacturers' 1920 weights for the chassis, body, and rated capacity, giving the total weight when loaded to rated capacity. The percentage distribution of weight recommended by the manufacturers of trucks for front and rear axle load was used as a standard for computing overloads on the front and rear axle. To be conservative $% of the total chassis, body and capacity weight was added to the manufacturers' given weight in deriving the standard for computing overloads. One-half of this 5% was added to the front and rear axle weights in arriving at a standard for measuring overloads per axle.

Commodities Overloaded

The practice of overloading per capacity is not confined to loads of heavy material such as sand, gravel, brick, etc.

It is restricted to no typical group of commodities, but is almost universal.

Apples, beer, butter and eggs, drugs, fish, furniture, groceries, lumber, meat products, paper, rubber goods, sugar, vegetables, wire are typical commodities of which overloads per capacity were noted.

Of the cases of overloading per capacity observed, 75% was practiced by regular trucking vehicles, 25% by irregular trucks.

Commodity loads exceeding 25,000 lb. were noted in the case of such commodities as brick, butter, drugs, eggs, glass, groceries, litharge, meat, plumbing supplies, sugar, vegetables and vinegar.

Of the number of loads exceeding 25,000 lb. 87.8% were overloads per capacity; 88.7% were by regular trucking companies. Thirty-nine out of 41 cases were loaded from 846 to 1,560 lb. per inch of tire width on the rear axle.

Composition of Truck Traffic

Only 4.2% of trucks observed were over 5-ton capacity. The percentages of other capacities noted were as follows:

Capacity in tons	Per cent of total number	Capacity in tons	Per cent of total number
¼	0.4	4	1.1
½	8.0	4½	0.6
¾	11.0	5	12.7
1	12.2	5½	2.0
1¼	0.9	6	0.5
1½	6.0	6½	0.4
2	16.0	7	0.2
2½	10.4	7½	1.1
3	2.4	8	0.06
3½	10.0		

Width of Truck Body

The least width of truck body observed in the two censuses was 5 ft.; the greatest width in either census was 9 ft., 6 in. Only 6% of all trucks observed in the first census and 5% in the second census were equipped with bodies exceeding 7 ft., 6 in. in width.

Classification of Truck Weight by Type of Tire

Pneumatic tires were observed in use principally on the lighter trucks; solid tires on the heavier trucks and a combination of pneumatic and solid on the rear and front wheels respectively principally in the weight classification from 3,000 to 14,000 gross weight in pounds. The use of pneumatic tires increases rapidly from 2,000 to 5,000 lb. and then decreases rapidly to 10,000 lb. The number in excess of 10,000 lb. is negligible. The greatest percentage of trucks equipped with pneumatics occurs in the 4,000 to 5,000 lb. class. Solid tires begin to increase rapidly at 5,000 lb.

Classification by Weight of Trucks

The density of movement was found to be between the 4,000 and 14,000 lb. classes, 1,378 out of 2,183 observed trucks falling in these classes. Only 51 out of 2,183 or 2.3% exceeded 25,000 lb. Only 7 out of 2,183 weighed more than 28,000 lb.

Truck Weights Per Inch of Tire Width

In the first census 29 of 226 trucks, 12.8%, were found to have front axle loads in excess of 800 lb. per inch of tire width.

138 out of 359, 38.44%, were found to have rear axle loads in excess of 800 lb. per inch of tire.

167 of 585 or 28.55%, were loaded to more than 800 lb. per inch of tire width on both axles.

Overloads on the front axle range from 800 to 1,100 lb. per inch, density occurring at 900 lb.

Overloads on the rear axle range from 800 to 1,650 lb. per inch, density occurring at 1,100 lb.

In the second census the per cent. and range of overloads were as follows:

Front axle	11.9%	800-1500 lb., density	950 lb.
Rear axle	36.5%	800-1925 lb., density	1100 lb.
Both axles	24.6%		

In both censuses the number of overloads increases as tire thickness increases to 1.5 in. and decreases above that thickness.

Truck Overloading Per Capacity

The weighted average overload per capacity (computed on basis of standard already defined) is 39%. This is construed to mean that every third truck was loaded beyond the capacity of the truck and tires. A total of 37.5% were overloaded on the rear axle, and 40% were overloaded on the front axle.

Recommendations Based on Overloading Analysis

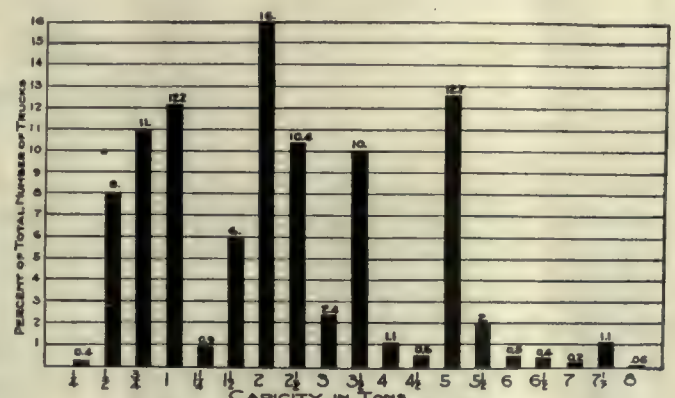
1. Classification of highways.
2. Seasonal restriction of loads.
3. Prohibition of overloads per capacity, and restriction of tire to 800 lb. per inch width.
4. Maximum body width of 7 ft., 6 in.
5. Maximum axle loads to be determined for each make and class of trucks and placed in conspicuous place on the vehicle.

Commodity Analysis

The 20 commodities noted in greatest bulk in the second census with the weight and average haul of each are as follows:

Commodity	Weight in Pounds	Average haul in Miles
Groceries	1,039,469	44.15
Furniture	553,545	71.47
Beer	421,665	72.92
Sugar	404,640	47.26
Household goods	375,495	99.81
Meat products	334,410	42.75
Rubber goods	279,020	82.96
Vegetables	176,893	37.68
Poultry	159,760	32.67
Cocoa beans	158,518	33.12
Merchandise	153,831	42.88
Wire	145,550	66.50
Grapes	141,220	48.56
Bananas	133,627	47.13
Dry goods	133,360	43.79
Feed	131,140	27.10
Silks	125,305	110.22
Lumber	119,805	35.51
Machinery	115,875	89.10
Litharge	114,370	106.25

The longest average hauls reported were those of boats and yeast, each of which was hauled an average distance of 150 mi. The volume of these commodities hauled were: Boats, 840 lb.; yeast, 10,445 lb.



COMPOSITION OF TRUCK TRAFFIC

The shortest haul reported was that of charcoal, 2,150 lb. of which were hauled an average distance of 3.50 mi. The next shortest haul was milk, 4,725 lb., of which were hauled an average of 5.80 mi.

Agricultural products make up only 14.3% of the traffic in the second census; manufactures and miscellaneous 72.5%, indicating, according to the report, that truck movement in Connecticut is predominantly that of manufactured goods of high value and small bulk.

Because the survey was limited to one season all agricultural products are not represented in the list of commodities.

The average haul of agricultural commodities is 39.5 mi.; the longest, eggs, is 68.21 mi.

Extending observed weights and hauls during the period of the second census it is estimated that the annual ton-mileage of agricultural commodities is 86,649.

Estimated value of agricultural products hauled both ways over Boston Post Road at Greenwich, based on observations of the second census $15,075,000.

Comparison of Truck and Railroad Traffic

Comparing the truck traffic observed in the second census with traffic over the New York, New Haven and Hartford and Boston and Maine Railroads, the results are as follows:

	By Truck	By N.Y.,N.H.& H. (1918)	By Bos.& Me. (1920)
Products of Agriculture	14.3	9.4	11.8
Products of Animals	11.2	3.3	3.2
Products of Mines	0.5	42.5	36.8
Products of Forests	1.5	6.5	13.2
Mfrs. & Misc.	72.5	38.3	3.50

Total observed eastbound truck traffic, second census, 239,562 ton-miles.

Adjusted to give 24-hour traffic for the 2-week period, 360,000 ton-miles, eastbound.

Seventy-one per cent of eastbound traffic loaded; thirty-six per cent of westbound traffic loaded.

Estimated traffic both ways for 2-week period, 540,000 ton-miles.

Assuming this traffic to be average for the year the annual east and west movement at Greenwich is estimated at 14,040,000 ton-miles of pay freight.

The average haul of truck movements was 47.44 mi.

TO BUILD MONTANA FOREST ROADS

At a recent meeting of the Montana State Highway Commission with representatives of the Forest Service and of the Bureau of Public Roads, the projects were definitely selected on which the Montana forest roads allotment of the Federal Highway Act of 1921 should be spent. Montana's share of the appropriation of that year for the construction and maintenance of forest roads and rails amounted to $887,000. The program, as it stands at present, calls for the expenditure of $700,000 on nine projects. The number of miles that this sum will construct is as yet unknown as a survey to determine the quantities has not been made and it is impossible to estimate the mileage that the money available will build without any idea of the quantities. The construction of these roads will open to tourist and local traffic many inaccessible parts of the state in which local funds have not been available for road improvement.

Citizens of Sullivan County, Indiana, have started a movement which is known as the "Donate-a-Day" road improvement plan. Throughout the country men are devoting one day to improving the roads in their immediate vicinities.

U.S. DEPARTMENT OF AGRICULTURE
BUREAU OF PUBLIC ROADS

FEDERAL AID STATUS

FINANCIAL STATEMENT

AS OF MARCH 31, 1922.

STATES	FEDERAL AID APPORTIONED F.Y. 1917 TO 1922	FEDERAL AID UNDER CONSTRUCTION e	AVAILABLE FOR NEW CONSTRUCTION	FEDERAL AID COMPLETED f	UNCOMPLETED FEDERAL AID ON PROJECTS UNDER CONSTRUCTION	AMOUNTS FEDERAL AID PAID STATES	BALANCE FEDERAL AID EARNED	STATES
ALABAMA	$ 7,329,973	$ 3,353,301	$ 3,976,672	$ 2,285,366	$ 1,067,935	$ 1,830,295	$ 455,071	ALABAMA
ARIZONA	4,824,633	3,283,457 a	1,541,176	2,986,231	297,226	2,420,583	565,648	ARIZONA
ARKANSAS	5,874,072	4,315,077	1,558,995	3,635,586	679,491	2,867,992	767,594	ARKANSAS
CALIFORNIA	10,846,453	6,864,607	3,981,846	5,116,975	1,747,632	3,282,684	1,834,291	CALIFORNIA
COLORADO	6,121,240	3,609,809	2,511,431	2,914,907	694,902	2,451,641	463,266	COLORADO
CONNECTICUT	2,170,222	1,142,106	1,028,116	868,741	273,361	479,267	389,478	CONNECTICUT
DELAWARE	813,280	447,655	365,625	447,115	540	437,458	9,657	DELAWARE
FLORIDA	4,034,938	2,889,671	1,156,267	1,184,627	1,696,044	738,407	446,220	FLORIDA
GEORGIA	9,465,536	7,293,348 a	2,112,188	6,711,453	581,895	6,288,386	423,067	GEORGIA
IDAHO	4,298,926	3,218,995	1,079,931	3,210,477	8,518	2,940,102	270,375	IDAHO
ILLINOIS	15,270,548	11,731,510 a	3,539,038	11,706,266	25,264	10,396,565	1,309,681	ILLINOIS
INDIANA	9,374,148	3,726,274 a	5,647,874	2,992,761	733,513	2,292,897	699,866	INDIANA
IOWA	10,042,216	7,512,479 a	2,529,737	6,721,476	791,003	5,491,148	1,230,328	IOWA
KANSAS	9,997,591	6,633,871 c	3,363,720	5,295,641	1,338,230	4,300,483	995,158	KANSAS
KENTUCKY	6,787,243	4,457,296 a	2,329,947	3,261,700	1,195,596	2,584,516	677,184	KENTUCKY
LOUISIANA	4,739,514	3,634,055 a	1,105,457	3,416,030	218,025	3,019,460	396,570	LOUISIANA
MAINE	3,341,124	2,609,747 a	731,377	1,961,143	648,604	1,572,226	388,917	MAINE
MARYLAND	3,031,378	2,346,039 a	685,339	2,293,399	52,640	2,220,169	73,230	MARYLAND
MASSACHUSETTS	5,148,741	2,711,872	2,436,869	2,535,413	176,459	1,208,582	1,326,831	MASSACHUSETTS
MICHIGAN	10,210,878	5,859,101	4,351,777	4,818,190	1,040,911	4,426,625	391,565	MICHIGAN
MINNESOTA	8,938,380	8,449,095	1,489,285	7,151,112	1,298,583	6,728,157	422,955	MINNESOTA
MISSISSIPPI	6,246,449	4,186,025	2,060,424	3,124,017	1,062,008	2,408,689	715,328	MISSISSIPPI
MISSOURI	11,770,204	5,043,294 a	6,726,910	3,580,421	1,462,873	2,931,312	649,109	MISSOURI
MONTANA	7,045,713	3,538,156	3,107,557	3,645,355	292,799	3,236,308	881,047	MONTANA
NEBRASKA	7,447,951	4,601,202	2,846,749	4,432,585	168,617	3,228,863	1,203,722	NEBRASKA
NEVADA	4,480,713	1,460,312	3,020,401	1,291,841	168,471	1,154,113	137,728	NEVADA
NEW HAMPSHIRE	1,508,714	1,092,584	416,130	1,029,374	63,148	1,013,832	15,544	NEW HAMPSHIRE
NEW JERSEY	4,208,170	1,760,239 a	2,447,931	1,605,751	154,488	1,326,565	279,186	NEW JERSEY
NEW MEXICO	5,579,618	2,710,316 b	2,869,302	2,237,525	682,791	1,870,509	367,016	NEW MEXICO
NEW YORK	17,385,250	6,905,622 a	10,479,628	3,537,110	3,368,512	2,996,038	541,072	NEW YORK
NORTH CAROLINA	7,980,025	6,119,991 a	1,860,074	5,787,630	332,321	4,925,962	861,668	NORTH CAROLINA
NORTH DAKOTA	6,387,202	3,378,287	3,008,915	2,954,280	424,007	2,364,400	589,880	NORTH DAKOTA
OHIO	13,025,952	8,043,551	4,982,401	7,756,680	286,871	6,973,175	783,505	OHIO
OKLAHOMA	8,090,586	5,534,202	2,556,383	3,248,908	2,285,294	3,188,050	60,858	OKLAHOMA
OREGON	5,514,842	4,296,637 a	1,218,205	4,291,609	5,028	4,122,055	169,554	OREGON
PENNSYLVANIA	16,031,598	12,432,498 a	3,599,100	12,311,517	120,981	10,377,551	1,933,966	PENNSYLVANIA
RHODE ISLAND	1,006,791	637,611	369,380	576,279	61,132	575,853	426	RHODE ISLAND
SOUTH CAROLINA	5,007,865	8,499,453	1,508,402	2,727,375	772,078	2,453,518	273,857	SOUTH CAROLINA
SOUTH DAKOTA	5,656,943	3,876,841	1,780,102	3,029,030	847,811	2,197,850	831,180	SOUTH DAKOTA
TENNESSEE	7,875,830	5,965,922	1,909,908	3,312,182	2,653,740	2,392,234	919,948	TENNESSEE
TEXAS	20,525,577	12,707,136 a	7,818,441	9,852,027	2,855,109	8,753,183	1,098,844	TEXAS
UTAH	3,966,624	1,977,213	1,989,411	1,611,992	341,221	1,095,446	516,547	UTAH
VERMONT	1,607,729	712,251 cd	895,478	607,063	105,188	553,142	53,921	VERMONT
VIRGINIA	6,909,559	2,775,439	4,133,120	3,161,796	971,346	3,025,602	136,172	VIRGINIA
WASHINGTON	5,075,396	1,225,900	849,376	4,100,375	115,634	3,842,614	257,761	WASHINGTON
WEST VIRGINIA	3,724,844	3,055,689	669,175	2,547,233	508,456	2,280,723	266,510	WEST VIRGINIA
WISCONSIN	7,899,047	5,613,532 a	3,285,565	5,206,557	406,975	4,889,266	317,291	WISCONSIN
WYOMING	4,213,176	2,934,473	1,278,703	2,501,339	433,074	2,129,525	371,814	WYOMING
TOTALS	$ 339,875,000	$ 216,892,629	$ 122,982,371	$ 101,572,485	$ 35,320,144	$ 134,282,021	$ 27,290,464	TOTALS

NOTE: a - REDUCTION DUE TO PAYMENT OF FINAL VOUCHERS. b - CORRECTION. c - REDUCTION DUE TO WITHDRAWAL OR CANCELLATION OF PROJECTS. d - DIFFERENCE DUE TO REVISION OF PROJECT STATEMENT OR AGREEMENT ESTIMATES. e - INCLUDES PROJECTS ENTIRELY COMPLETED. f - INCLUDES COMPLETED PORTIONS OF PROJECTS UNDER CONSTRUCTION.

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

Founded January, 1892

E. L. POWERS
Editor

461 EIGHTH AVENUE
NEW YORK, N. Y.

Cable Address: Gudrodes, New York

Copy for advertisements must reach the New York office by noon on Tuesday of the week before date of issue if proofs are to be submitted.

Copy for classified and other advertisements where proofs are not required will be accepted until noon on Monday of the week of issue.

Articles by road builders are solicited. They should be short and, if possible, accompanied by photographs. Those accepted will be paid for at current rates.

Vol. LXII. May 10, 1922 Number 19

SEGREGATION OF MOTOR TRUCKS

Indicative of the growing importance of the motor truck in the transportation system of this country is the decision of the Connecticut State Highway Department to construct a 30-mi. highway for the exclusive use of motor trucks. This plan will be submitted to the Legislature next year for approval.

So great has become the volume of passenger and truck motor traffic between the large urban centers of the East that serious congestion has resulted, and it is probable that the construction of roads for the segregation of motor traffic will receive much attention during the nex few years.. Not only will the construction of this motor truck road in Connecticut relieve traffic congestion on the Boston Post Road between Greenwich and Bridgeport, but it will afford an excellent opportunity to study the effect of intense motor truck traffic upon road surfaces.

HIGHWAY LEGISLATION IN CONGRESS

The Dunn bill, which appropriates $65,000,000 for federal aid during the next fiscal year and $75,000,000 for the year ending June 30, 1924, was passed by the House on May 1 by a vote of 239 to 31. The chief objection to the bill was made by Representative Begg of Ohio who declared it to be "a raid on the Treasury." He made this statement in spite of the fact that he had voted for the soldiers' bonus.

The bill now goes to the Senate and, if passed, to conference. The Senate Committee on Post Offices and Post Roads attached a rider to the post office appropriation bill allotting $190,000,000 additional federal aid and $15,000,000 for forest roads. The House Committee on Roads were not inclined to accept this rider, which was not included in the bill as it passed the House, necessitating a conference on that feature, but are demanding consideration of the Dunn bill which was introduced in the House by Chairman Dunn of the committee. The rider merely appropriates money to be spent under the provisions of the original federal aid act but the Dunn bill amends the federal aid law and makes several changes in the present procedure. A synopsis of these changes was printed in these columns in this issue of April 19.

The Arizona Highway Department believes that the provisions of the Dunn bill will work hardship in Arizona and other public land states in the west and the Nevada Highway Department emphatically states that it should not pass. The main objection is to the clause which reduces the per mile limit of federal participation to approximately one-half that provided in the present law. Many of those interested in highway improvement also feel that the appropriations are not large enough to provide for the satisfactory development of our highway program during the next two years.

FEDERAL AID STRENGTHENED

Federal aid has done a great deal more for the country than simply to provide funds for road construction, according to the Bureau of Public Roads. One of the most far-reaching results has been its influence in placing the greater part of the highway work of the country in the hands of experienced engineers of state highway departments.

In 1915, prior to the Federal Aid Act, 70 per cent of the road work was done by agencies other than state highway departments, most of it by county officials. Overhead costs were high, engineers were not always employed, systems to serve the best interests of the state as a whole were not developed, and the opportunities for corruption were greater.

With the passage of the Federal Aid Act of 1916 and the insistence of the government upon the construction of Federal Aid roads under the supervision of state departments, existing state highway departments were enlarged and strengthened, and in 17 states adequate departments have been created where there had been none or the existing one was not properly equipped to perform necessary functions.

With adequate departments the work has been shifted to their control until at the present time they supervise more than 60 per cent of the road work. This assures to the taxpayer the services of engineers trained in road work, a centralized authority responsible for the expenditure of funds, and a far-sighted plan of development and financing.

Equipment — Trade — Materials

PAVER EQUIPPED WITH RUBBER TIRES

The use of rubber tires on heavy construction machinery is an interesting feature of a motor-driven Rex Paver just completed by the Chain Belt Company, Milwaukee, Wis., for a street railway company. This machine is to be used principally for paving between

REX PAVER WITH RUBBER TIRES

tracks where the paving outside the tracks has been previously completed. The tires prevent damage to the finished paving as the machine moves along with the job. Also, in traveling from job to job over highly finished city streets, the paver can be moved at a good rate of speed without danger of damage to either pavement or machine.

DIESEL ENGINE TO OPERATE NEW SHOVEL

The Bucyrus Company has introduced a 1-yd. revolved shovel operated by a Diesel type engine. The shovel itself is of the same improved type as the gasoline shovel which was placed on the market a few months ago. The importance of the new development lies principally in the outstanding fact of fuel cost as the Diesel type engine, will use any cheap, low-grade oil of high heat value which will flow freely.

The manufacturer claims for this shovel a rough average fuel cost of $1 to $1.25 per day as against an estimated daily fuel cost for a coal burning shovel of $9 per day.

The engine is what is known as the full Diesel type, not the semi-Diesel, and is a mechanical injection engine developing 55 hp. at 360 r.p.m. Its cylinders are 8 in. by 10½ in. The Diesel type engine differs from the gasoline engine principally in that it is a constant pressure engine, the fuel being burned directly in the cylinders without the aid of a carburetor, spark plugs, or other outside heating appliances. In the Diesel type engine, the fuel is injected into the cylinders at a constant pressure in an atomized state and is fired by the heat developed by the compression in the cylinders on the previous stroke. Thus the sudden pressure due to the explosion in the gasoline engine is eliminated, making the engine steadier running and easier to maintain.

This shovel, known as the Bucyrus 30-B oil shovel, may be furnished either as a shovel, a dragline, a clamshell or a locomotive crane.

CATERPILLAR TRACTION FOR SHOVELS

Of interest to users of railroad-type shovels, as well as to prospective purchasers, is the announcement of the Bucyrus Company that it is prepared to equip all sizes of that type of shovel with caterpillar traction. The chief advantage of caterpillars lies in the fact that a shovel so equipped can be moved more easily and quickly with consequent saving of labor and time. For transportation by rail, railroad trucks may be easily substituted.

BUILT TO ENDURE

"Built to Endure" is the title of a booklet recently published by the Koehring Company, of Milwaukee, Wis., which sets forth in an interesting manner comparative examples of notable ancient and modern construction embodying the element of permanency. Well written, tastefully designed, and illustrated with etchings in color, this booklet is decidedly a noteworthy and attractive road publication.

THE "STERLING" CONVERTIBLE LEVEL

The "Sterling" Convertible Level is a new model for the use of builders, architects, and construction engineers manufactured by the Warren-Knight Co. of Philadelphia, Pa. The instrument is so designed that it can be converted from a level to a transit in ten seconds without throwing it out of level. This change is accomplished without the use of detachable parts. Besides the quick-change feature, the level possesses many exclusive improvements.

The Stockland Road Machinery Co. of Minneapolis, Minn., has issued its 1922 Good Roads Manual, a handsome illustrated booklet which contains, in addition to descriptions of Stockland machines, various information and suggestions about road building.

The use of steel forms for street and highway con-

struction is described and illustrated in a catalogue published by the Heltzel Steel Form and Iron Co., of Warren, Ohio.

ROAD MATERIAL SURVEYS LESSEN COSTS

Road material surveys now being made in several states will give contractors a more definite basis for bidding on road work and result in cheaper costs of construction, says the Bureau of Public Roads.

In making these surveys, supplies of stone, gravel, sand, slag and other materials are located, samples tested and information secured as to accessibility, freight rates, and other factors. This information is of permanent value as supplies are rarely exhausted. By furnishing a contractor information as to the location of satisfactory materials one element of risk is removed, and some of the states report that they have definite proof that such service has resulted in decreased bids.

The Bureau of Public Roads in the course of its operations has tested some 9,000 samples of rock, sand, gravel and slag, and reports are available giving the location from which the sample was taken, together with results of tests. There are now 68 laboratories engaged in testing road materials, and data is being rapidly accumulated even in states that are not at this time making an intensive survey.

SOUTH CAROLINA NUMBERS HIGHWAYS

In addition to direction and distance signs, the South Carolina State Highway Department has marked all the established roads of the state highway system with numbers which correspond with numbers on the road map of the department. The new numbers are painted on boards inside of a black and white outline of the state and are nailed to telephone poles or other convenient objects along the road, at prominent points. By means of these numbers, any traveler who will refer to the department map can find his way between any two points on the state highway system.

ROAD BUILDING COSTS IN WISCONSIN

A. R. Hirst, Chief Engineer of the Wisconsin Highway Department, has announced that the 400 mi. of concrete road to be constructed in that state this year will cost less than the 350 mi. built in 1921. A comparison of the average costs of building an 18 ft. concrete road, exclusive of surveys and inspection, for the years 1921 and 1922, show a decrease during the 122-month period of nearly $9,000. The 1922 cost is estimated at $25,383 per mile. The drop in the cost of grading during the same period is 31 per cent.

THE OUTDOOR LEAGUE OF AMERICA

The Outdoor League of America was organized at the meeting of the National Federation of Outdoor Clubs which was held at St. Louis, April 26. Dr. W. H. Taylor of Denver was elected president; Emerson Hough, the novelist, of Chicago, vice-president; and Charles F. Hatfield of St. Louis, secretary. The mission of the league is to inculcate and increase an intense and general love of nature, interest in outdoor sports, and an understanding of the value of outdoor activities in connection with good citizenship.

STATUS OF FEDERAL AID IN MONTANA

The March report of the State Highway Department of Montana shows that $6,800,000 has been expended by the department on federal aid projects in the years 1919, 1920, 1921 and three months of 1922. This construction has brought to the state an amount of federal money substantially over $3,000,000. The total length of projects completed is over 500 mi. and 220 mi. are now under construction contract, many of them nearly complete. The 1922 contracts will increase this mileage sizeably. The report indicates that 16 mi. of roads have been surveyed during March and a total of 37 mi. of surveys have been made in 1922.

BRICK HIGHWAY FOR INDIANA

The Indiana State Highway Commission has awarded the contract for the construction of the first brick road to be built by the state. The road is a section of the National Road 6.897 mi. in length, and is to be constructed of bituminous filled brick on a concrete base. The bid price was $219,916, approximately $111,000 more than the low bid for concrete pavement for the road. The award of this contract marks a new departure in the policy of the highway commission which has heretofore refused to award any contracts for brick construction on the ground that the cost was excessive in comparison with concrete.

FEDERAL AID ROAD CONSTRUCTION

Federal aid roads completed since 1916 totaled 11,017 mi. on March 31, an increase of 8,016 mi. during the preceding 12 months, says the Bureau of Public Roads. A great many different types and widths were constructed, the general average cost per mile for the United States being $17,120. In total mileage completed the leading states were Minnesota 1,093 mi., Texas 919, Wisconsin 657, Illinois 489, Ohio 465, and Arkansas 401.

The Montana State Highway Department has completed a new state highway map which is the most complete and accurate road map of the state yet compiled. It is the plan of the department to have a small size printed in folder form for general distribution.

The Austin Machinery Corporation, at the annual meetings of stockholders and board of directors held recently in Richmond, Va., and New York, N. Y., elected the following officers: B. A. Linderman, president; John R. Shaw, vice-president; William Werntz, secretary; J. R. Keppel, treasurer.

MEETINGS

Calendar of Coming Meetings

May 12—National Highway Traffic Association—Annual meeting, Automobile Club of America, New York City. Secretary, Elmer Thompson, 247 West 54th St., New York City.

May 26-27—Dixie Highway Association—Annual convention, Jacksonville, Fla. Secretary, M. B. Roberts, 302 First National Bank Bldg., Chattanooga, Tenn.

June 4-6—American Association of Engineers—Annual convention, Salt Lake City, Utah. Secretary, C. E. Drayer, Chicago, Ill.

June 12-15—Canadian Good Roads Association—Ninth annual convention, Victoria, B. C. Secretary-treasurer, George A. McNamee, Birks Bldg., Montreal, Canada.

June 26-July 1—American Society for Testing Materials—Twenty-fifth annual meeting, Atlantic City, N. J. Secretary, C. L. Warwick, Engineers' Club Bldg., Philadelphia, Pa.

Aug. 9-10—Custer Battlefield Highway Association—Annual meeting, Sheridan, Wyo. Secretary, W. D. Fisher, Sheridan, Wyo.

Oct. 9-13—American Society for Municipal Improvements—Annual convention, Cleveland, O. Secretary, Charles Carroll Brown, St. Petersburg, Fla.

PROGRAM FOR A. S. T. M. MEETING

The American Society for Testing Materials has sent to its members the provisional program for the annual meeting of the society which is to be held in Atlantic City, N. J., during the week of June 26. The first day will be devoted to registration and committee meetings. There will be twelve business sessions, beginning Tuesday morning, June 27, and ending Friday evening, June 30. Two sessions will be of special interest to road builders; the eighth session, "On Concrete Aggregates, Road Materials, and Waterproofing," at 8 p. m. on Thursday, and the twelfth session, "On Cement and Concrete," at 8.00 p. m. on Friday. The reports of the committees on lime, drain tile, and brick will be made at the tenth session at 9.30 a. m. on Friday. While this arrangement is subject to change, every effort will be made in arranging the final program to make as few changes as possible.

CONFERENCE ON STATE PARKS

The Second National Conference on State Parks will be held at Bear Mountain Inn, Palisades Interstate Park, New York, from May 22 to 25. The aim of the conference is to stimulate interest in state park systems, especially with a view to the acquisition of lands suitable for preservation in all the states while they can be acquired cheaply. The subject is of interest to promoters and builders of improved highways because of the fact that good roads are necessary to open such reservations to the public.

NATIONAL CHAMBER OF COMMERCE TO DISCUSS HIGHWAY TRANSPORT

Highway transport in all its phases will be discussed at the highway transport section of the annual meeting of the Chamber of Commerce of the United States which takes place at the Masonic Temple, Washington, D. C., on May 16. T. H. MacDonald, Chief of the Bureau of Public Roads, will speak first on "Economic Foundation for Future Highway Progress." He will be followed by E. J. Mehren, Editor of the Engineering News-Record, who will discuss, "Practical Highway Transport Regulation." There will be a general discussion following the presentation of the addresses.

PERSONAL MENTION

D. E. Harrington, Assistant City Engineer of Madison, Wis., has resigned to enter the engineering and contracting business.

Gabriel Henry, Chief Engineer of the Department of Roads, Province of Quebec, has been appointed superintendent of provincial roads and highways.

Harry S. Leyden, Chief Inspector of Highway Construction of Fresno, Cal., has been appointed county superintendent of highway construction and maintenance.

J. J. Hedrick, Jr., of Tampa, Fla., County Engineer of Hillsborough County, has resigned to enter the contracting field. Allan Pimm, his assistant, has been appointed county engineer.

L. A. Doan, formerly assistant engineer of bridge construction with the Indiana State Highway Commission, has been appointed assistant district engineer in charge of bridges for the upper peninsula of Michigan.

Fred Emerson, Assistant City Engineer of Lockport, N. Y., has been appointed city engineer of Batavia, N. Y.

W. B. Spencer, dealer in road-building equipment, has moved his offices from 150 Nassau street to 30 Church street, New York City.

The Maryland State Roads Commission plans to spend $4,800,000 this year, $3,000,000 for construction of improved highways and $1,800,000 for maintenance of the existing system.

GOOD ROADS

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Vol. LXII May 17, 1922 Number 20

TABLE OF CONTENTS

*Distribution of Wheel Loads on Pavement Sections. By H. F. Clemmer and C. A. Hogentogler . . . 273
Illinois Prepares New Road Oil Specifications. By H. F. Clemmer 280
To Organize American Construction Council . . 281
To Make Report on Good Roads 281
Hard Surface Roads in Missouri 281
Texas Objects to Dunn Bill 282
Would Vote Bond Issue in Virginia 282
Propose Federal Automobile Tax 279

EDITORIALS:

The Highway Traffic Association 279
Road Building a Process 279

PUBLICATIONS:

American Road Builders' Association 1922 Proceedings 282

MEETINGS:

Calendar 283
National Highway Traffic Association Holds Meeting 283
A. R. B. A. Holds Annual Meeting 284

PERSONAL MENTION 284

*Illustrated Article

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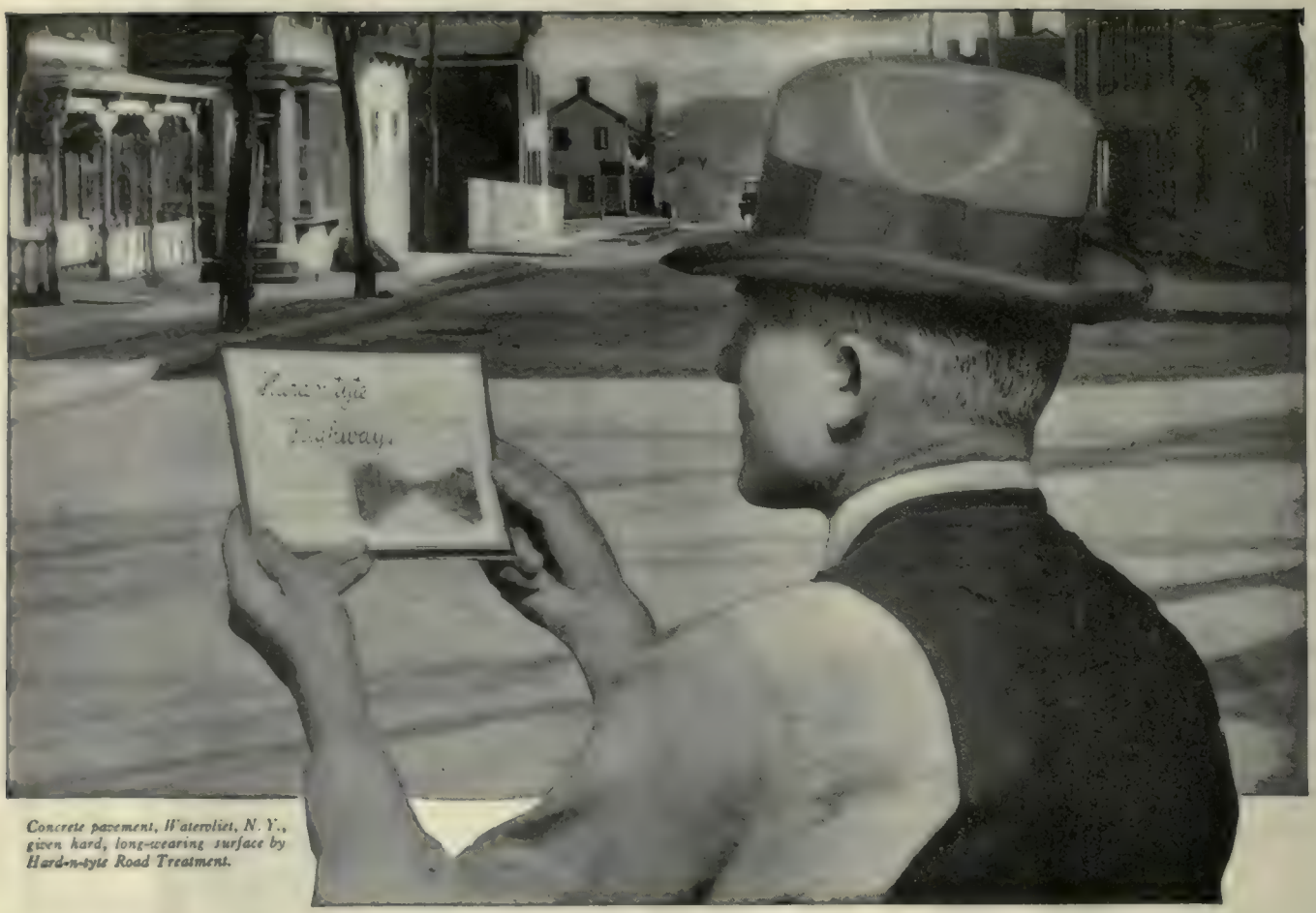

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GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

WITH WHICH IS INCORPORATED

THE HIGHWAY CONTRACTOR AND ROAD BUILDER

Vol. LXII. NEW YORK, N. Y., MAY 17, 1922 No. 20

Distribution of Wheel Loads on Pavement Sections*

By H. F. CLEMMER† and C. A. HOGENTOGLER‡

Part of the investigational work carried on at the Bates Experimental Road, under the direction of Clifford Older, Chief Engineer of the Illinois Division of Highways, consisted of observations for determining the deflections of the various surfaces, and corresponding pressures delivered to the subgrade during the passage of heavy motor truck wheels. The behavior of corners adjacent to joints, as well as other parts of the sections, were observed. Ames dials, supported independently of the pavement, were used for measuring deflections and subgrade pressures were obtained by means of pressure cells which were supplied by the U. S. Bureau of Public Roads. During construction, 25 cells were placed in the road, 12 being in corners 18 in. from both the joint and the side edge, and 13 in other parts of the sections. The procedure in pressure cell installation and manipulation was similar to that used on the Camp Humphrey road test.[1] Types of pavements observed were monolithic, semi-monolithic, concrete and bituminous filled brick on macadam base.

For obtaining information at the corners, pressures and readings on two Ames dials, one each side of the joint 1 in. from the side edge of the pavement, were taken when the rear wheel of a motor truck, which was moved across the joint, was placed at intervals of 1 ft. for a distance of 4 ft. each side of the joint and at intervals of 2 ft. through a distance of from 4 to 18 ft. each sid eof the joint. Observations at points other than corners were made in a manner similar to that described above, excepting that one Ames dial was used instead of two. This dial was supported on a ¾-in. iron rod driven 4 ft. into the subgrade through the surface at a point from which a test core was taken. A record also was made of pressures, deflections, and air temperatures, both before and after each set of observations. Moisture content of subgrades was determined at each point observed. The motor truck used had front and rear wheel weights of 3,340 and 7,150 lb. respectively.

In all, six sets of observations were made, one about noon and one about midnight on both August 8 and October 25, 1921, as well as day runs on March 6, and April 17, 1922. From noon and midnight sets, it was hoped to learn more about the effects of slab warping, a discussion of which has been given in a previous paper,[2] while those taken at several different times of the year were expected to show effects of season changs.

This work rquired taking about 2,000 pressure cell and 6,000 dial readings, from which were secured about 150 influence curves. These influence curves show (1), the distances from points observed at which the influence of the wheel load was felt, and (2), the pressures exerted on the subgrade by such deformations as were caused by surface deflections. In addition to the above, the curves secured from corner loadings disclose the ability of joints to transfer loads on one section, to the adjacent section, and also the vertical movement of the two sections due to the fact that perfect contact between the two did not exist.

A study of the corner curves failed to show any definite relation between deflection and load, or deflection and thickness of surface. Without exception, however, the deflections at night were greater than those which occurred in daytime, showing clearly that during the cooler part of the day, due to warping, the edges of rigid road slabs are curled upward, while in the warmer part, they are curled downward. In addition to this curling, and due to the same cause, temperature change, there was noted also longitudinal contraction and expansion of the sections, allowing better distri-

*Report of one of the highway research investigations carried on by the Illinois Division of Highways, the U. S. Bureau of Public Roads cooperating.

†Engineer of Tests, Illinois Division of Highways.

‡Highway Engineer, U. S. Bureau of Public Roads.

[1]Thickness of Concrete Slabs, by A. T. Goldbeck, Public Roads, April, 1919.

[2]Bates Experimental Road, by Clifford Older, read at meeting of American Association of State Highway Officials at Omaha, Neb., Dec. 8, 1921.

bution of the load across joints during the day than at night.

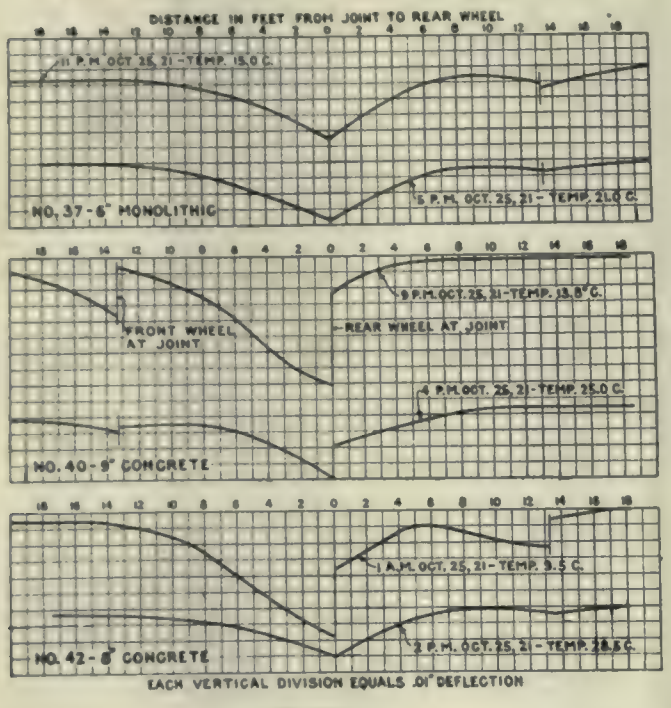


FIGURE 1

Typical corner influence curves are shown in Fig. 1. The curves for section No. 37 indicate that, at the joint between the monolithic sections No. 37 (3-in. brick and 3-in. base) and 38 (4-in. brick and 3-in. base), perfect contact existed both day and night. The curves for section No. 40 indicate that, at the joint between these two 9-in. concrete slabs, very little connection existed either night or day. This condition was due to the fact that the original joint was chiseled out to a width of one inch and later filled with Portland cement grout. The curves for section No. 42 indicate that, at the joint between the 8- and 7-in. concrete slabs, excellent contact existed during the day and but very little at night, thus showing the effect of longitudinal contraction and expansion due to temperature changes. A scrutiny of these curves shows that the greater deflections occur at night. In section No. 37, where perfect contact existed, the difference between day and night deflections was but .008 in.; in section No. 42, where perfect contact existed only during the day, the difference was .048 in.; and in Section No. 40, where perfect contact existed at neither time, the difference in deflections was .041 in. This indicated that the warping was considerably less when perfect contact between sections existed.

The curves in Fig. 2 show the behavior of corners on opposite sides of the joint when a truck wheel passes from one side to the other. When contact between sections is not perfect, a movement occurs which causes the ends of the slabs, if they are close enough together, to rub against each other, which action can cause shattering, or feathering, of the joints. Between sections Nos. 44 and 45, where no contact exists, the movement, or distance, of rubbing was .187 in. In sections Nos. 51 and 52, where partial contact was indicated, this rubbing distance was slightly more than .1 in., notwithstanding the fact that the total deflections are about the same as those of Nos. 44 and 45. Between sections Nos. 40 and 39, where perfect connection existed, the rubbing movement was completely eliminated.

Since the observed deflections, because of different conditions of contact between sections, were caused by varying loads, it was necessary before comparisons were made to know the deflections which would have occurred had the same conditions of contact existed at the joints. By assuming perfect contact, values were obtained from the formulae shown in Fig. 3, and furnished a basis of comparison. These values are only approximate since the assumption made in their derivation was that the deflection of the corner varied directly as the load. These computed values, together with the observed deflections and the total movements, or distances, of rubbing for the day and night readings on October 25, 1921, are given in Table I.

The joint between sections Nos. 44 and 45, which showed the greatest movement, was filled with bituminous concrete, while that with the next greatest movement, taking into consideration the thickness of the slab, was filled with Portland cement grout. All other joints had corrugated metal, without dowels, between the sections.

The two joints which showed the least movement were between the two monolithic sections Nos. 38 and 37 and between the monolithic and concrete sections Nos. 40 and 39.

Table I shows very clearly the decrease in observed deflections and total movements during the day and, while the percentages of distribution are only approximate, they show clearly the increased contact during the day. In the daytime, for all sections observed,

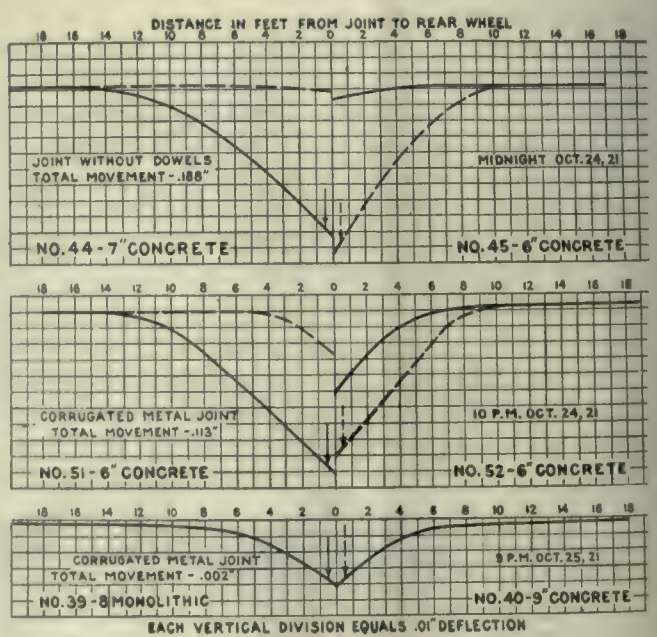
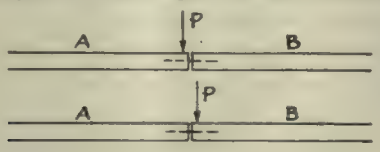


FIGURE 2

the average deflection was .026 in. less, the average rubbing distance was .039 in. less, and the per cent distribution of load across the joint was 8.8 in. greater than at night. The night observations show but 7



Let a_1 = deflection of slab A when load P is on slab A
" b_1 = " " " B " " " " " A
" a_2 = " " " A " " " " " B
" b_2 = " " " B " " " " " B
" f_A = " " " A when slab A takes entire load P
" f_B = " " " B " " B " " "

Then $\frac{a_1}{f_A} \cdot P + \frac{b_1}{f_B} \cdot P = P$

$\frac{a_2}{f_A} \cdot P + \frac{b_2}{f_B} \cdot P = P$

or $\frac{a_1}{f_A} + \frac{b_1}{f_B} = 1$ --------(1)

$\frac{a_2}{f_A} + \frac{b_2}{f_B} = 1$ --------(2)

from which

$$f_A = \frac{a_1 b_2 - a_2 b_1}{b_2 - b_1} \quad ---(3)$$

$$f_B = \frac{a_1 b_2 - a_2 b_1}{a_1 - a_2} \quad ---(4)$$

If perfect contact exists between slabs A and B, load P produces equal deflections in both slabs, or $a_1 = b_1 = a_2 = b_2$. Substituting values for f_A and f_B in equations (3) and (4) in equation (1) or (2), the deflection

$$f_{AB} = \frac{a_1 b_2 - a_2 b_1}{(a_1 - a_2) + (b_2 - b_1)} \quad (5)$$

in which a_1, a_2, b_1 and b_2 are the observed deflections

FIGURE 3

joints offering 40 per cent, or more, distribution, while during the day 11 show this condition. Comparing both the observed values and those computed for the condition that adjacent slabs have perfect contact, it can be noted that:

1. The difference in computed deflections between night and day was considerably less than in the observed deflections. The computed difference for corners acting independently was .039 in.; that for the observed deflections, .026 in.; and that for assumed perfect contact, but .017 in.

2. On October 25th, the average deflection for 7,150 lb. load at night was .059 in., while for 3,340 lb. it was .017 in., which indicated that deflections did not vary directly as the load. This difference in daytime for the two loads is again different, being .042 in. for 7,150 lb. and but .009 in. for 3,340 lb. That is, at night, a 53 per cent load reduction shows 71 per cent less deflection, and, during the day, the same load reduction is accompanied by 79 per cent reduction in deflection.

The distances through which the influence of the wheel load was exerted ranged from 16 to 26 ft. but, because of the different percentages of load acting, no definite comparisons could be made. In general, the deflections observed in August agreed with those of October, in some cases being slightly greater and, in others, slightly less. The computed deflections for March were but slightly greater than for October. The average of total movements in March was slightly less than in October.

The observations taken in April showed less deflections and slightly greater movement between slabs than those in March or October. Since these readings were taken after 1,600 applications of the truck loads, it would indicate that the effect of traffic loosened the joints somewhat and also caused the surface to have increased subgrade support.

Subgrade Support as Indicated by Pressure Cells

The influence curves secured from pressure cells placed in the bottom of the pavement were similar to those derived from the Ames Dial readings showing the deflections of the various sections, thus indicating that a definite relaton existed between deformation of subgrade and its corresponding supporting power. In other words, for the type of soil under the Bates Road the term, "supporting value of so many pounds per square inch," is intelligible only when the deformation of soil accompanying such pressure is known. For this reason, the term, "pressure in pounds per square inch for a definite amount of deformation," is used in the following discussion.

The relations between subgrade pressures and deflections of the surface are clearly shown by the curves in Fig. 4. Curves No. 31 (3½ in. concrete base, 1-in. sand cement cushion, 3-in. lugless brick, grout filled) for day and night show this relation for corners having little contact. At both times the pressure curves are identical with the deflection curves. The upward warping at night, again, can be noted. Pressure without load during the day was .1 lb. per sq. in., while at night this pressure was not attained until the corner was deflected .003 in. The maximum pressure at night was .1 lb. greater than that at day, being 3.9 instead of 3.8 lb. per sq. in. The corresponding deflection at night was .004 in. greater than at day, being .047 rather than .043 in. Subtracting the initial deflection noted above of .003 in., there results an increase in pressure of .1 lb. per sq. in. for an increase in corner deflection of .001 in. Since the deflections of the slab at the pressure cell location which was on the diagonal 2 ft. from the corner, were somewhat less than those recorded at the corner, it would seem that the supporting value of the soil under the cell at this time was somewhat greater than 1 lb. per sq. in. for each .01 deformation. The moisture content was 31.5 per cent.

Curves No. 37 (monolithic, 3-in. brick top, 3-in. concrete base), night and day, show the relation between pressure and deflection as found at a joint where perfect contact existed between the adjacent sections. In this case, the pressures both night and day without load were zero. With load, the pressure at night was .5 lb. greater than during the day, being 2.3 lb. instead of 1.7 lb., while the increase in deflection at night

was .008 in. greater than during the day, being .042 in., rather than .034 in. In these curves, it was indicated that after the pressure exceeded 1 lb. per sq. in. the bearing value of the subgrade was similar to that noted for No. 31; that is, somewhat greater than 1 lb. per sq. in. for each .01 in. deformation. The moisture content was 29.2 per cent.

Curves No. 42 show the relation between pressure and deflection at a point 18 in. from the north side edge of an 8-in. concrete section. Again, the similarity between the two is very noticeable. With a deflection of .02 in. there was a pressure increase of 3.4 lb., indicating that the bearing value of the soil was about 1.7 lb. per sq. in. for each .01 in. deformation. The moisture content of the soil was 31.2 per cent. In these curves, the influence of the front wheel, as well as that of the rear, is very noticeable. The increase in pressure due to the front wheel, .8 lbs. per sq. in., was about 25 per cent of that caused by the rear wheel, 3.4 lbs. per sq. in., which relation is similar to that noted above as existing between the corresponding deflections at the corners of the slabs.

In curves No. 56 (5-in. concrete) the surface deflections observed are compared with the pressures as shown at the top of the subgrade, as well as those found in 6 in. below the top. There is little difference between these two pressure curves except that the one for the top of the subgrade seems to be slightly more sensitive to surface deflection than the one 6 in. below. Also, slightly greater pressure is shown for the former than for the latter. When the rear wheel exerts its greatest influence upon the point of observation, the bearing value at the top of the subgrade is 2.2 lb. per sq. in. for each .01 in. deformation, while for a point 6 in. below the top, the increase in pressure is but 1.8 lb. per sq. in. for each .01 in. deflection of the surface. That this cell is close to a transverse crack in the surface is very clearly shown by the curves. The lower pressures seem to increase .1 lb. per sq. in. for each .01 in. deflection of surface. The moisture content is 29.2 per cent.

In Table II, are given locations of cells and pressures observed with and without wheel load. It will be noted that, in a considerable number of cases, no pressures were recorded. This can mean either that there was no contact between the subgrade and the surface, or that the cell did not record such contact as existed. Considering the second possibility, there have been cases in which poor manipulation of the cells has created permanent deformation directly under the diaphragm which makes future readings useless. This, however, can only occur in a soil in which there is little elasticity. For instance, if too great an air pressure is allowed to enter the cell, the diaphragm can be pushed down a maximum of something less than .05 in. If the soil has no elasticity, a permanent deformation at this point is caused which indicates no contact for future readings. The soil under the Bates road, however, is extremely elastic. Experiments have shown that, under pressure, this soil can be deformed .1 in. repeatedly, returning always to its original shape. Also each cell given in Table II has been tested by suction and found to be in perfect working order. It is, therefore, believed that, in most cases, the zero readings indicate lack of support at the observed points. It will be noted also that many more zero readings were found at corners than at other parts of the sections. For instance, of the 44 corner observations made without load, but 5 showed contact, while out of 47 readings, taken at other parts of the slabs without load, 24 showed contact. Under the 7,150 lb. wheel load, 18 out of 42 corner points showed contact and 32 out of 47 observations at other points indicated the same condition. From these figures, it would seem that, especially under corners, subgrade support under a rigid pavement is extremely variable. Whether the lack of contact between surface and subgrade was local, being only at the cell position, or whether it extended some distance around the cell position was not determined. If, in addition to the daily warping of slabs caused by temperature change, there is a gradually progressive warp caused by the fact that the top of the slab is more or less dry, being subjected

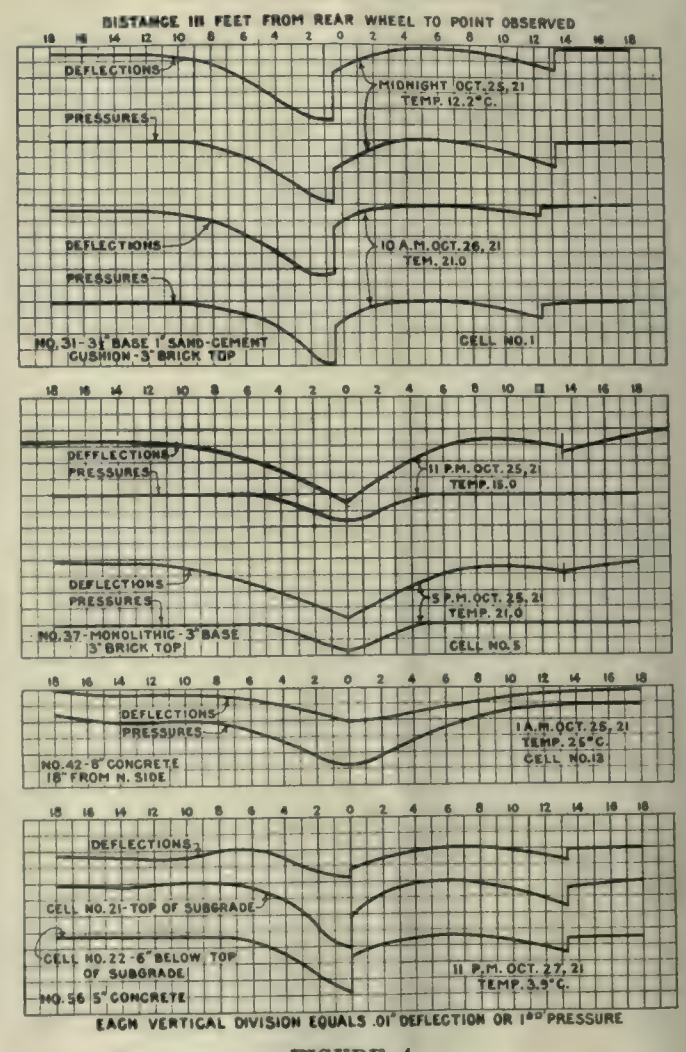


FIGURE 4

to the air and sunshine while the bottom is in contact with the moist subgrade, the lack of support at the corners would be accounted for.

Considering the pressures with the observed deflections, the upward warping of the edges of the slab at night was again very apparent. For instance, cell No. 8, under the corner of section No. 40 from readings taken Aug. 8th, indicated that, at night, .061 in. corner deflection was required to bring the cell location in contact with the subgrade and, in the daytime, support at this point was shown by a corner deflection of but .071 in., from which it would appear that distance between subgrade and surface at right was considerably greater than in daytime. Also, for securing contact under the cell in section No. 51 in October, a corner deflection of .037 in. was required at night and but .010 in. at noon, and in August, .014 in. was required at night and but .005 in. in the daytime, indictating again the difference in separation between day and night.

The greatest pressures were observed under Section No. 5, cell 29, (8-in. macadam base, 2-in. mastic cushion, bituminous filled 3-in. lugless brick top). As could be expected, pressures were indicated without load as well as with load. The maximum under load was 18.2, 26.6 and 28 lb. per sq. in., being about five times as great as any pressures observed under the rigid type of pavement. Also, the distance through which the load was distributed in this case differed from all the others, being but 4 ft., while, as noted before, with the rigid types, this distance ranged from 16 to 26 ft. The increase in pressure of 16.5 lb. per sq. in. in October was caused by a surface deflection of .147 in., while the increase of 26.2 lb. per sq. in. in August was accompanied by deflection of .287 in. These deflections observed on the surface at the side of the wheel were without doubt somewhat smaller than those which occurred directly under the wheel, thus indicating again that the resistance, or bearing value, of the soil was something greater than 1 lb. per sq. in. for each .01 in. deformation.

Of the 12 corner cells which registered more than 1 lb. per sq. in. pressure, 9 consistently showed support somewhat in excess of 1 lb. per sq. in. for each .01 in. deformation. Seven cells which recorded less than 1 lb. per sq. in., indicated no relation between pressure and deflection. This bears out the result of previous experiments from which it was indicated that, after initial pressure had been applied, the soil had a definite bearing value.

A very interesting condition of support was found under section No. 42 in which the cells Nos. 9, 10, 11, 12 and 13 were placed respectively 18 in. from the south side, 4½ ft. from the south side, in the center, 4½ ft. from the north side and 18 in. from the north side. Without load at night, support was indicated only under the quarter point on the south side and the 18 in. point on the north side; during the day, in addition to the above locations, slight support was indicated also at the center. Under load there was no support indicated either for the 18-in. point on the south side or the quarter point on the north side, but on the 18 in. point on the north side about 5 lb. was shown; on the quarter point on the south side, about 3 lb.; and only .6 lb. in the center. With support of this kind, the cracking of a pavement under load can easily be understood. In every case, the pressure shown by cell 11 in the center was greater in the daytime than at night, thus indicating greater deflection at the former time. Since, from previous experiments, it was indicated that this condition of increased center support can occur only with the presence of a

TABLE I.

TABLE SHOWING OBSERVED AND COMPUTED DEFLECTIONS OF SLAB CORNERS ADJACENT TO JOINTS

			Oct. Night Obs. Deflection				Oct. Day Obs. Deflection				Inc.	Dec.	Computed Equal Deflections for Both Slabs at Joint					
	Section		Load on Near Side	Load on Far Side	% Load Carried Across Joint	Total Movement of Corners	Load on Near Side	Load on Far Side	% Load Carried Across Joint	Total Movement of Corners	% Dist. Day & Night	Total Move. Day & Night	Rear Wheel			Front Wheel		
No.	Thick	Kind											Night	Day	Diff.	Night	Day	Diff.
40	9 in.	Conc.	.081	.024	13.0		.040	.019	35.0		22.0							
40	9 in.	Conc.	.066	.012	26.0	.111	.042	.021	30.0	.042	4.0	.069	.046	.031	.015	.016	.008	.008
40	9 in.	Conc.	.041	.040	49.0		.035	.035	50.0		1.0							
39	8 in.	Mono.	.040	.039	49.0	.002	.035	.035	50.0	.0	1.0	.002	.040	.035	.005	.009	.006	.003
42	8 in.	Conc.	.078	.037	43.0		.030	.030	50.0		7.0							
43	7 in.	Conc.	.050	.030	26.0	.061	.030	.030	50.0	.0	24.0	.061	.047	.030	.017	.011	.007	.004
63B	7 in.	Conc.	.075	.026	15.0		.055	.026	18.0		3.0							
63A	7 in.	Conc.	.070	.015	29.0	.104	.047	.014	38.0	.062	9.0	.042	.046	.038	.008	.016	.008	.008
44	7 in.	Conc.	.094	.004	11.0		.060	.011	18.0		7.0							
45	6 in.	Conc.	.106	.009	5.0	.187	.076	.016	15.0	.109	10.0	.079	.057	.040	.017	.016	.007	.009
38	7 in.	Mono.	.045	.045	50.0		.037	.037	50.0		0.0							
37	6 in.	Mono.	.045	.045	50.0	.00	.037	.037	50.0	.00	0.0	.00	.045	.037	.008	.012	.008	.004
48	6 in.	Conc.	.085	.035	47.0		.048	.043	41.0		6.0							
47	6 in.	Conc.	.092	.060	20.0	.082	.044	.038	46.0	.011	26.0	.071	.070	.044	.026	.025	.011	.014
51	6 in.	Conc.	.114	.095	20.0		.076	.059	28.0		8.0							
50	6 in.	Conc.	.105	.063	33.0	.061	.079	.050	44.0	.046	11.0	.015	.098	.066	.432	.028	.018	.010
52	6 in.	Conc.	.094	.053	15.0		.086	.050	49.0		35.0							
51	6 in.	Conc.	.101	.027	46.0	.115	.073	.008	46.0	.101	0.0	.012	.078	.057	.031	.024	.015	.009

NOTE:—Equal deflections of both corners at joints indicates perfect contact or 50% distribution.

longitudinal crack or joint, an inspection of the section was made and such a crack was found.

Observations on slab No. 42 also furnish information on the relation between the deflection occurring at different points of the slab. The greatest deflection noticed in the center of the slab was .006 in.; that at points 18 in. from the sides of the slab, .020 in.; that at the corner, under best conditions of contact, .040 in.; and that computed for corner without any contact with adjacent slabs, .080 in. If deflection is an indication of stress, the corners apparently are the least resistant parts of the slabs. The cell readings, taken on April 17, 1922, after 1,600 applications of traffic load, indicated that support at the corners was slightly better than that found before the traffic was started.

TABLE II
PRESSURES OBSERVED UNDER VARIOUS PAVEMENT SECTIONS

No.	Section Thick	Kind	Cell No.	Location	Without Load October Night	October Day	August Night	August Day	April Day	7150 Wheel Load October Night	October Day	August Night	August Day	April Day	Maximum Observed Without Load
40	9 in.	Conc.	8	Corner	0	0	0	0	1.1	0	0	.2	.6	2.7	0.8
42	8 in.	Conc.	14	Corner	0	0	0	0	0	0	0	0	0	0*	0
44	7 in.	Conc.	16	Corner	0	0	0	0	0	0	0	0	0	2.2	0.4
63B	7 in.	Conc.	25	Corner	0	0	0	0	0	0	0	0	0	0	
47	6 in.	Conc.	17	Corner	0	0	0	0	0	0	0	0	0	0	1.1
51	6 in.	Conc.	18	Corner	0	0	0	0	0	1.9	2.2	1.4	.2	0	0
52	6 in.	Conc.	19	Corner	0	0	0	0	0	.1	.1	.1	.1	1.3	.4
31	8 in.	Semi-Mono.	1	Corner	0	.1	0	.3	0	3.9	3.8	2.6	2.7	0	.4
35	6 in.	Mono.	3	Corner	0	0	0	0	0	0	0	0	1.8	0	.5
37	6 in.	Mono.	5	Corner	0	0	—	0	.1	2.3	1.7	—	.2	3.6	4.5
33	8 in.	Mono.	6	Corner	0	0	—	—	1.4	0	0	—	—	3.2	0
5	12 in.	Br. on Mac. B	29	Corner	1.7	.4	—	1.8	.8	18.2	26.6	—	28.0	31.0	
40	9 in.	Conc.	7	Center	0	.1	—	.1	0	.2	.7	—	.1	0	2.1
42	8 in.	Conc.	9	South Side	0	0	0	0	0	0	.3	0	0	.4	.7
			10	S. ¼ Pt.	1.7	—	1.7	.3	0	3.4	—	3.0	2.7	1.2	4.2
			11	Center	0	.1	0	.3	0	.5	.8	.6	1.1	.5	1.3
			12	N. ¼ Pt.	0	0	0	0	0	0	0	0	0	0	.9
			13	N. Side	1.4	1.8	—	2.7	2.2	4.9	4.8	—	5.6	4.9	8.7
63B	7 in.	Conc.	26	S. ¼ Pt.	.9	0	—	.1		1.8	.7	—	.8		
44	7 in.	Conc.	15	Center	1.0	.7	.7	.3	.5	1.6	1.4	1.7	1.5	1.3	1.6
52	6 in.	Conc.	20	Center	0	0	—	0		2.0	1.3	—	4.9		3.1
56	6 in.	Conc.	21	Center *	.9	1.4	1.9	2.8	2.3	4.5	4.5	5.7	4.8	4.3	4.0
			22	Center **	.1	.1	1.9	2.3	2.7	4.6	4.0	6.7	5.6	5.2	7.0
35	6 in.	Mono.	2	Center	0	0	0	0		0	0	0	0		5.7
37	6 in.	Mono.	4	Center	0	0	0	0	0	0	0	0	0		2.8

*Cell in sub-grade 6 in. below bottom of pavement.
**Cell on sub-grade at bottom of pavement.

General observations to be made from the foregoing results are:

1. That, after initial pressure has been applied, the soil has more or less definite bearing value, being slightly greater than 1 lb. per sq. in. for .01 in. deformation under the Bates road. Also, that the supporting value of the soil apparently was less in March than in either August or October.

2. That the support under a rigid surface is extremely variable, indications being that the surface rests on small mounds of the subgrade and has little or no support in other areas.

3. That the condition of least support is found under the corners of sections. This support, however, was improved by traffic action.

4. That the distance through which the influence of the load was felt on an 8-in. macadam base was much less than that on an 8-in. concrete, while the corresponding pressure on the former was about five times as great as on the latter, indicating that a soil of much higher supporting value is required for a pavement on an 8 in. rolled stone base than is required for an 8 in. rigid type of pavement. The pressure exerted on the subgrade could be reduced by increasing the thickness of the rolled stone base.

5. That the effect of temperature change is very noticeable in rigid pavements causing both warping and longitudinal expansion and contraction. The effect of this temperature change was least in two joints, one between two monolithic sections and one between a monolithic and a concrete section.

6. That the deflection of an independent corner was about 13 times, and that of a confined corner, about 6½ times that found at the center of the slab, indicating that the corner is the part of the slab which most deserves investigation.

7. That neither the pressure nor the deflections, as observed at corners, varied directly with the magnitude of the load.

8. That considerable movement can occur between the edges of adjacent slabs when there is not perfect contact between them, this movement being the cause possibly of shattering the edge, or feathering about the joint. That this movement is slightly increased by traffic.

9. That, if perfect contact can be secured between adjacent edges of slabs, all movements between them will be eliminated; the deflections will be lessened and the effect of warping between night and day will be considerably reduced.

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

Founded January, 1892

E. L. POWERS
Editor

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Copy for advertisements must reach the New York office by noon on Tuesday of the week before date of issue if proofs are to be submitted.

Copy for classified and other advertisements where proofs are not required will be accepted until noon on Monday of the week of issue.

Articles by road builders are solicited. They should be short and, if possible, accompanied by photographs. Those accepted will be paid for at current rates.

Vol. LXII. May 17, 1922 Number 20

THE HIGHWAY TRAFFIC ASSOCIATION

Too much importance can not be attached to the work of the National Highway Traffic Association which has just held its annual meeting in New York City. This organization is unselfishly carrying on a work which is essential to the development of an adequate system of highways in the United States and should be backed up by everyone interested in highway transportation.

The condition of highway transport in the country at this time may be, to a large degree, compared to the condition of railroad transportation in Europe to-day. Especially in eastern Europe, where the provisions of the Versailles Treaty created a number of independent countries in the territory formerly governed by the German Empire and Russia, the regulations governing transportation by rail are so varied and conflicting that travel and shipment of goods by rail is most uncertain and unreliable. With the tremendous strides in the development of highway transport in this country, the different regulations obtaining in the various states threaten to cause a like chaotic condition in travel and shipment of commodities by motor.

There is a crying need for uniformity of methods of construction and design, highway signs, traffic regulations, and laws controlling the shipment of freight by motor truck and it is to that end that the National Highway Traffic Association is working. The association is composed of men of broad experience in road construction and motor transportation, men of vision who are able to forecast the needs of the future, and is admirably fitted to carry on the work it has begun. Other organizations in the same field, less specialized in their purposes and more local in character, should cooperate with this organization to the fullest extent.

ROAD BUILDING A PROCESS

Theodore Gary, Chairman of the Missouri State Highway Commission, upon his return in April from a two months' trip abroad, made the following statement in regard to his investigations of road conditions in England and on the Continent:

"But one thing I have gained by my investigations, especially in England, and that is corroboration of my contention that road building is a process. The road must be built up and maintained and I am going to convince the people of Missouri of this. Lay the foundation for a good road. Open the road and use it. Then surface it. The usage to which it has been put has packed and knit the material so firmly that you know you have a permanent foundation that will stand up for all time."

Few road builders would fail to agree with the general correctness of Mr. Gary's contention that it would be ideal to construct roads a layer at a time over a period of years and the traffic on the roads of Missouri may be such that the method, which he describes, would be feasible there, but, in many states of dense population and heavy traffic highways, there is not time for it. The development of motor transport will not wait for the road builder. It is already ahead of the development of road construction and the highway engineer faces the necessity of designing a type of road which will stand up under the pounding of the heavy motor trucks, and that right quickly.

The proposition to build a foundation road and allow it to be used and beaten down before it is surfaced will do for secondary roads but, for trunk lines, it does not seem to fill the bill. The foundation road would not carry the heavy traffic without considerabe damage, the construction at two different periods would increase the expense, and the road would have to be closed a second time during the surfacing. There is not time for such a method of construction.

PROPOSE FEDERAL AUTOMOBILE TAX

A bill has been introduced in Congress by Representative Mills of New York which requires that every automobile be stamped with a federal registration number at a cost of $2 to the owner. The measure is designed to cut down the number of motor car thefts, not as a revenue getter, but it would produce approximately $26,000,000 the first year and $6,000,000 each succeeding year. At a hearing before the House of Ways and Means Committee, prosecuting attorneys sponsored the bill and representatives of the state automobile associations appeared in opposition.

Illinois Prepares New Road Oil Specifications

By H. F. CLEMMER†

The ever increasing use of road oils in the State of Illinois has prompted a considerable amount of laboratory investigation and practical research, the results of which have done much to enable the highway department to prepare its new set of road oil specifications. As a great many factors have bearing upon the satisfactory use of these oils, specifications covering the quality of the material have in the past been only a means of rejecting the poorest of grades. The present specifications are expected to do considerable in bringing about the oiling of roads to a better advantage in so far as economy and service are concerned.

The oiling of roads in this state has past the embryonic stage where the expense and results are not to be considered. In 1921 there were 7,000 mi. of roads oiled in Illinois at a total cost of approximately $1,500,000. Over 25,000,000 gallons of road oil was used in this work. The cost of this material amounted to about 5 ct. per gallon delivered with the cost of application amounting to 1 ct. per gallon. The average cost of oiling a mile of road in 1921 ran beween $200 and $250.

Increasing public interest in oiled roads has created a demand for more information relative to the best methods of applying oil, the comparative merits of different kinds of oil, and the types of oil to be used on various kinds of soils. The great lack of uniformity in applying oil to roads has been the subject of considerable discussion for some time and investigations in this as well as other problems relating to the use of oil are wanted. The Illinois Highway Division has recognized this want and has made considerable progress in the investigational field. A far greater number of experiments are now being planned and will be executed within a short time. The University of Illinois has also come to the same conclusions and consequently are planning extensive investigations in road oils. Under the direction of the Engineering Experiment Station a 12-mi. experimental road is now being constructed upon which various problems attending the oiling of roads will be taken up.

During the past few years, the Laboratory of the Division of Highways has tested several thousand samples of road oil and has collected much valuable information regarding the quality of oils from various sources and results obtained from their use under various conditions existing in Illinois. The activities of the laboratory through its testing and work in preparing specifications has had the result of gradually improving, both in respect to uniformity and quality, the oils which are being used in this state. The most noteworthy feature of present road oil practice in Illinois is the tendency toward the use of heavier oils. A few years ago practically all oil used contained between 40 and 50% asphaltum, heavy oils being considered unsafe or unsatisfactory to use. Figures compiled by the laboratory show during 1921 that 70% of all oil used in the state was purchased to contain 50 to 60% asphaltum, 16.5% to contain more than 60% asphaltum, and only 13% to contain less than 50%. Recognizing this condition, the laboratory has prepared the following specifications and it is probable that practically all oil purchased in the state during this season will be purchased under these or very similar specifications.

Specifications for Oil for Earth Roads

Specifications E-1

(These specifications admit Mexican and similar asphaltic base petroleum residuums. Semi-asphaltic base petroleum when refined by certain processes may yield residuum meeting with these specifications.)

1. The road oil shall be homogeneous and free from water. It shall meet the following requirements:
2. Specific gravity 25°/25°C. (77°/77°F.), not less than 0.930.
3. Specific viscosity at 40°C. (104°F.), 25.0 to 75.0
4. Loss at 163°C. (325°F.), 5 hours, not more than 25%.
5. Total bitumen, not less than 99.5%.
6. Per cent. of total bitumen insoluble in 85/B. naphtha, 7.0 to 18.0.
7. Flash point, not less than 60°C. (170°F.).
8. Per cent. of residue at 100 penetration, 50 to 60.

Specifications E-2

(These specifications admit petroleum residuum refined from petroleum from Texas, Louisiana, Oklahoma, Kansas, Illinois, and other semi-asphaltic petroleums. Oils meeting the requirements of specifications E-1 will be acceptable under specifications E-2.)

1. The road oil shall be homogeneous and free from water. It shall meet the following requirements:
2. Specific gravity at 25°/25°C. (77°/77°F.), not less than 0.900.
3. Specific viscosity at 40°C. (104°F.), 25.0 to 75.0
4. Total bitumen (solubility in carbon disulphide), not less than 99.5%.
5. Per cent. of residue at 100 penetration, 50 to 60.
6. Flash point, not less than 80°C. (175°F.).

Specifications E-3

(These specifications admit either asphaltic base or semi-asphaltic base petroleum residuums of a heavier grade than covered by specifications E-1 and E-2.)

1. The road oil shall be homogeneous and free from water. It shall conform to the following requirements:
2. Specific gravity 25°/25°C. (77°/77°F.), not less than 0.930.

†Engineer of Tests, Illinois State Highway Department.

3. Specific viscosity at 100°C. (212°F.), 2.0 to 6.0.

4. Total bitumen, not less than 99.5%.

5. Per cent. of residue at 100 penetration, 60 to 70.

Tests of the physical and chemical properties of the road oil shall be made in accordance with the following methods:

1. Specific gravity—U. S. Dept. of Agriculture, Bulletin 949, Test No. 19, p. 36.

2. Specific viscosity—U. S. Dept. of Agriculture, Bulletin 949, Test No. 27, p. 44.

3. Loss on heating—A. S. T. M. Standards, 1921, Serial Designation D6-20, p. 731.

4. Total bitumen (solubility in carbon disulphide)—U. S. Dept. of Agriculture, Bulletin 949, Test No. 20, p. 38.

5. Naphtha solubility—U. S. Dept. of Agriculture Bulletin 949, Test No. 22, p. 40.

6. Flash point—U. S. Dept. of Agriculture, Bulletin 949, Test No. 24, p. 42.

7. Percentage of solid residue of 100 penetration—U. S. Dept. of Agriculture, Bulletin 949, Test No. 28, p. 45.

Specifications E-1 and E-2 may be considered as alternate specifications covering oil for cold application or which would require only slight heating. Specifications E-3 admit oil of a somewhat heavier grade than covered by the E-1 and E-2 specifications. This grade is best suited for hot application on soils of a somewhat sandy nature or on roads which have been previously treated with a lighter oil.

TO ORGANIZE AMERICAN CONSTRUCTION COUNCIL

As an outgrowth of the conference of the Federation of Construction Industries held in Chicago in April, a meeting will be held in Washington, D. C., June 19 and 20 to complete the formal organization of the American Construction Council. This organization will bring together for betterment of understanding and common action architects, engineers, general contractors, sub-contractors, construction labor, labor contractors, materials and equipment manufacturers and dealers, bond, insurance and real estate interests; all the elements connected with construction work of any description. It has for its purpose the coordination of the work of the 250 national associations in the industry so that there may be the elimination of duplication and more resultful work. With the broader viewpoint of this all-embracing organization to work out the problems common to the associations, there is opportunity for tremendous waste elimination and better homes, public buildings, highways, railroads, etc. for the public in proportion to their expenditure.

Secretary of Commerce Hoover will preside at the meeting and Franklin D. Roosevelt, former Assistant Secretary of the Navy, has agreed to accept the presidency of the organization.

TO MAKE REPORT ON GOOD ROADS

The joint congressional commission of agriculture, which has been giving much attention to the subject of federal aid highways, is about ready to make a report in which it will urge congress to continue its support of the good roads movement.

The commission says that it will require heavy expenditures if the 2,500,000 mi. of highways in the United States are to be brought up to a standard of efficiency comparable to their extended use in motor transportation.

The commission will also ask that highway construction and maintenance be directed to more effective correlation of highway transportation with railroad and water transportation, and that states and counties also continue their highway programs with particular reference to farm-to-market roads.

The necessity of co-operation among the states to effect a uniform basis for taxing motor trucks and other motor vehicles, fairly to represent the proportion of highway expense chargeable to such vehicles, will be urged by the commission, it was said, as well as the need for uniform regulation of motor traffic.

Chairman Anderson, head of the joint commission, said that it is already clear that there is a wide variation in principle and application of the various state and local regulations affecting intrastate traffic. Studies of local motor transportation should be expanded as rapidly as possible to afford a definite basis for uniform regulation of motor transportation in order that the inconvenience, expense and inefficiency of operation occasioned by a lack of uniformity in state and federal legislation in the future may as far as possible be avoided.

The importance of motor transportation to the farmer was found not only to have been its effect in extending and broadening his markets, it was said, but in the sharply reduced cost of moving his produce to market. This was illustrated in the commission's estimate that in 1918 the cost of wagon haulage from farm to shipping point averaged about 30 ct. a ton mile for wheat, 33 ct. for corn and 48 ct. for cotton, while by motor truck or tractor the averages were 15 ct. for wheat and corn and 18 ct. for cotton.

HARD SURFACE ROADS IN MISSOURI

A recent compilation by the State Highway Department of Missouri of the records from the various counties of the state shows that there are 4,207 mi. of hard surface roads in Missouri. Of this mileage, 3,898 mi. are gravel macadam, 175 mi. are bituminous macadam, and 134 mi. are concrete and brick.

The Lincoln Highway Association has just published and is mailing to all of its members, as well as to the American press and all highway officials, a handsome illustrated booklet, entitled, "The Lincoln Highway, Its Eighth Year of Progress."

PUBLICATIONS

AMERICAN ROAD BUILDERS' ASSOCIATION. Proceedings of the Twelfth American Good Roads Congress. Paper, 6 x 9 in., 273 pages. Illustrated. Edited by Clifford Superior Lee. Published by the association, New York, N. Y.

This volume contains the papers presented at the congress of the American Road Builders' Association held in Chicago, Ill., last January, together with discussions of them. A large and comprehensive number of subjects are taken up by prominent men in the road field. The proceedings of the nineteenth annual convention and of the annual business meeting are also included in this volume. Many of the papers are illustrated with photographs and charts.

A superficial examination of this volume startles a technical man, who is accustomed to accuracy in every detail. The editing of technical works requires a knowledge of English, an understanding of the subject and editorial ability. A glance at this volume shows lack of these qualifications in its editor.

On the cover we find that this volume is the "Official Proceedings of the Twelfth American Good Roads Congress, Nineteenth Annual Convention and Annual Business Meeting of the American Road Builders' Association." From the index we find that the proceedings of the congress start on page one and the proceedings of the convention start on page 251. Yet throughout the book we find the running head on each odd-numbered page, "Convention Proceedings."

On the title page we find the remarkable statement, "Official Proceedings of the Twelfth American Good Roads Congress, Nineteenth Convention and Annual Business Meeting of the American Road Builders' Association, held at Chicago, Ill., January 17, 18, 19 and 20 1922, and at New York City, November 15, 1921, respectively."

The invocation on page one starts, "Please stand. O Lord, our God, we know that all our work should be begun." On page 13 we find a speaker saying, "In the absence of the principal speaker that we expected to have here today, your President has prepared a short paper." Other instances of this nature can be found throughout the book.

The customary abbreviations used in engineering literature are entirely absent in this book. Miles, square yards, pounds, etc., are invariably spelled out. For example, on page 178 we find "one-fourth of an inch," instead of the simpler form, ¼ in. All numbers, no matter how large, are spelled out. On page 205 we find "two thousand, five hundred and fifty-two," instead of 2,552. Even the daily papers use numerals for numbers for numbers larger than 100. Cuts are referred to as "plates."

An amazing display of ignorance of elementary mathematics is found in the derivation of the formula appearing on page 192. We find that a radical sign is thrown over one side of an equation without any effect upon the other side. Any high school boy knows that such a thing is impossible. The inclusion of such a glaringly incorrect algebraic problem in the official permanent records of the association is very unfortunate.

TEXAS OBJECTS TO DUNN BILL

The provision of the Dunn bill, now before Congress, which extends to five years the three year period granted in the original Federal Aid Act of 1921 for changing their constitution to permit them to comply with the terms of the act, does not meet with the approval of the highway commissioner and highway engineer of Teaxs. In a letter to all congressmen and senators from Texas, they state that such a change in the constitution of the state is vital at this time and that any further delay will only make matters worse.

Under the present laws, the State Highway Department does not have sufficient funds to match the federal aid dollar for dollar and has to depend on county bond issues for that purpose. Under that system, trunk line roads vary in type as they run from one county into another and frequently a county will vote no bond issue and an unimproved gap will be left. Of the 2,055 mi. of completed highways in the state, scarcely 100 mi. are in any one continuous stretch and very little of the completed road is being maintained.

Therefore, the highway commission feels that a change in the law should be made at once, that the three year provision will aid the promoters of good roads in influencing the legislature of next year to take such action, and that the proposed extension of the period of grace to five years would only defer action which should be taken now.

WOULD VOTE BOND ISSUE IN VIRGINIA

The Virginia Good Roads Association is sponsor for a statewide movement calling for a special session of the legislature for the purpose of pasing a $12,000,000 bond issue for state highway construction. The extra session would also be asked to pass a law placing a tax on gasolene to take care of the interest and retiring of the bonds. This sum is to pay for the road building program for the next two years.

The Illinois State Highway Department has inaugurated a new system of inspection of road construction to insure the correct execution of contracts. State engineers will be detailed to every job and, in addition, traveling inspectors will visit the work from time to time without announcing their coming.

The Paving Commission of Baltimore, Md., has available for new street paving in 1922, $2,500,000.

MEETINGS

Calendar of Coming Meetings

May 26-27 — Dixie Highway Association — Annual convention, Jacksonville, Fla. Secretary, M. B. Roberts, 302 First National Bank Bldg., Chattanooga, Tenn.

June 4-6—American Association of Engineers—Annual convention, Salt Lake City, Utah. Secretary, C. E. Drayer, Chicago, Ill.

June 12-15—Canadian Good Roads Association—Ninth annual convention, Victoria, B. C. Secretary-treasurer, George A. McNamee, Birks Bldg., Montreal, Canada.

June 26-July 1—American Society for Testing Materials—Twenty-fifth annual meeting, Atlantic City, N. J. Secretary, C. L. Warwick, Engineers' Club Bldg., Philadelphia, Pa.

Aug. 9-10—Custer Battlefield Highway Association—Annual meeting, Sheridan, Wyo. Secretary, W. D. Fisher, Sheridan, Wyo.

Oct. 9-13—American Society for Municipal Improvements—Annual convention, Cleveland, O. Secretary, Charles Carroll Brown, St. Petersburg, Fla.

NATIONAL HIGHWAY TRAFFIC ASSOCIATION HOLDS MEETING

Committee reports on questions of vital importance in relation to highway transport and interesting discussions thereof by members and guests marked two lively sessions of the annual meeting of the National Highway Traffic Association which was held in the assembly hall of the Automobile Club of America in New York City, Friday, May 12.

The afternoon session opened with the report of the National Committee on Uniform Highway Signs which was read by Elmer Thompson, chairman of the committee and secretary of the association. Mr. O. M. Wells of the Automobile Club of America explained a system of marking the highways of the country, advocated by that body, by doing away with existing signs of various types and substituting standard signs which would bear numbers for each highway corresponding to numbers on the road maps. The country has been divided into zones for the systematic development of uniform highway signs and the New England states, as the first zone, have already adopted this system. The meeting passed a resolution in favor of the adoption of the plan, as outlined, by all state highway departments.

The report of the National Committee on Traffic Capacity and Widths of Highways Outside of Municipalities was read by President Arthur H. Blanchard and precipitated a spirited discussion as to safe widths of heavy traffic roads. The report was a progress report and was voted received by the members.

Ten recommendations for standard practice were made to the association in the report of the National Committee on Status of the Construction of Highway Curves and Recommended Practice to Increase the Safety of Traffic which was presented by Chairman H. Eltinge Breed, consulting highway engineer of New York City. The report recommended certain standards for widening curves in proportion to the degree of curvature, a minimum radius of 300 ft., danger signs 500 ft. from each end of dangerous curves both vertical and horizontal, a painted line in center line of road on both horizontal and vertical curves, definite proposals for adequate shoulders and guard rail protection, the elimination of all advertising and other signs and obstructions from the highways, a definite appropriation annually by each highway department and a comprehensive plan for the elimination of dangerous grade crossings, and the passage of laws to make passing another motor vehicle going in the same direction on a curve, either horizontal or vertical, where the unobstructed vision is less than 500 ft., a misdemeanor. These recommendations were adopted by unanimous vote to be referred and recommended to the board of directors.

After the reports of the Executive Committee, the Treasurer, the Secretary, and the Board of Directors, had been presented, the session closed and dinner was served to the members and their guests.

To open the evening session, Chairman David Beecroft introduced Colonel Arthur Woods, President of the Automobile Club of America, who delivered the address of welcome. Colonel Woods spoke of the importance of the work being done by the National Highway Traffic Association and the opportunity afforded them at this time to work out a comprehensive plan for the development of the country's highways during the next fifty years so that all work could be done according to that plan and no effort wasted.

The response to the address of welcome was made by the president of the National Highway Traffic Association, Arthur H. Blanchard. After thanking Colonel Woods for his courtesy and the Automobile Club for their hospitality, Mr. Blanchard delivered a short address on, "The Railroads as an Operator of Highway Transport." The report of the National Committee on Regulations Covering Speeds, Weights and Dimensions of Motor Trucks and Trailers followed. The committee recommened the following maximum

dimensions for motor trucks; length 30 ft., width 96 in., heighth 12 ft. 6 in. and no maximum weights for solid tire trucks of 800 lb. per in. width of tire and 2,200 lb. axle loading. The report also set speeds for motor trucks from 15 to 25 mi. per hour, the speed varying according to the gross weight of the truck and also according to whether it is being operated in the city, or in the country. The discussion on this report was spirited and showed the great variance of opinion on the subject of limiting the size and weight of trucks between the road engineers and officials on the one hand and the motor truck operators on the other. The report was finally adopted by the meeting.

The chairman next introduced a speaker who was not on the program in the person of Dr. W. K. Hatt, Director of the Advisory Board on Highway Research, National Research Council. Dr. Hatt spoke briefly on "Research in Highway Transport," and brought out as the burden of his talk that the time when the promotion work of the road enthusiast was sufficient is past and that what is needed no wis research, experimentation and the consequent working out of problems by scientists.

The remaining reports were progress reports which recommended no definite steps for adoption by the meeting. The report of the National Commiftee on Highway Transport Franchises was read by Mr. Small, former member of the Public Service Commission of Missouri, and that on Highway Transport Clearing Houses b yTom Snyder, Secretary, National Association of Commercial Haulers, Indianapolis.

Before adjournment, Mr. Breed introduced two resolutions which were passed without dissenting vote. The first resolution stated that the National Highway Traffic Association is unalterably opposed to the provision of the Dunn bill, now before the Ways and Means Committee of the Senate, which reduces the per mile limit of federal participation in the construction of federal aid projects from $20,000 to $12,500 the first year and then to $10,000, and directed the secretary to so notify the Senate committee. The second resolution thanked the Automobile Club of America for extending to the association the hospitality of its club house.

The following officers were elected by unanimous vote:

President, Arthur H. Blanchard; Vice-Presidents, David Beecroft, L. A. Nares, R. C. Hargreaves, Jack F. Witt, C. M. Upham; Secretary, Elmer Thompson; Treasurer, George H. Pride.

Directors—W. T. Beatty, Roy D. Chapin, J. H. Collins, R. J. Corbitt, Charles Henry Davis, J. D. Eggleston, William P. Eno, John Fields, T. D. Guthrie, R. E. Hines, Thomas B. King, P. A. Koehring, Samuel P. Leeds, Irving W. Patterson, T. Coleman du Pont, F. A. Seiberling, Tom Snyder, William C. Spear, Samuel W. Taylor, J. DeMont Thompson, F. W. A. Vesper, George F. Wolz.

Executive Committee—Arthur H. Blanchard, Roy D. Chapin, George H. Pride, Tom Snyder, Elmer Thompson.

A. R. B. A. ELECTS OFFICERS

The annual meeting for the election of officers of the American Road Builders' Association was held at the Automobile Club of America in New York City on Monday, May 15. The Board of Directors, voting by ballot, elected the following officers for the coming year:

Vice-Presidents, Northeastern District, F. E. Everett of Concord, N. H.; Southern District, Frank Page of Raleigh, N. C.; Central District, J. Frank Smith of Kansas City, Mo.; Western District, Samuel Hill of Seattle, Wash.; Secretary, E. L. Powers of New York; Treasurer, James H. MacDonald of New Haven, Conn.

The balloting for president resulted in a tie and President H. L. Bowlby will continue to hold office until another election can be held.

The vote for seven members of the Board of Directors to take the place of those whose terms expire this year, which was taken by letter ballot throughout the entire membership, resulted in the election of the following:

Northeastern District, R. Keith Compton of Baltimore, Md., and George C. Diehl of Buffalo, N. Y.; Southern District, H. K. Bishop of Washington, D. C.; C. P. Fortney of Charleston, W. Va., and Warren R. Neel of Atlanta, Ga.; Central District, M. F. Bramley of Cleveland, Ohio; Western District, Frank Terrace of Orillia, Wash.

In addition to the election of officers, the association discussed various business throughout the afternoon and evening and enjoyed a get-together dinner between the two sessions. At the close of the evening session, the meeting voted to adjourn until June 15.

PERSONAL MENTION

George A. Read, formerly assistant state engineer of Vermont, has been appointed state engineer to succeed Daniel O. Young who resigned to enter the construction business.

Thomas J. Wasser, State Highway Engineer of New Jersey, has been elected president of the newly created state board for licensing professional engineers and surveyors.

George E. Finck has resigned as office engineer of the paving commission of Baltimore, Md., to accept the postion of highway engineer of Greensboro, N. C.

Ett S. Smith, Chief of the Division of Public Works in the Ohio State Highway Department, has resigned on account of ill health.

Alexander W. Graham, Chief Engineer of the Missouri State Highway Commission, has resigned.

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

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Vol. LXII May 24, 1922 Number 21

TABLE OF CONTENTS

*The Bronx River Parkway Drive. By L. G. Holleran 283
Good Roads and Flood Prevention 288
$2,000,000 for Roads in Nebraska 288
Forest Highway Projects Approved 288
Gas-Tar Protects Concrete Against Alkaline Waters 290
New Device Sets Standard for Smoothness of Roads 290
Types of Highways in New York 290
Crushed Stone Production Increases 290
Europe to Aid Motorists 290
Illinois Announces 1922 Road Program 290
City Planning Scheme for New York City Launched 291

EDITORIALS:

Importance of Highway Engineering 289
The Dunn Bill Should Not Pass 289
To Limit Truck Loads 289

MEETINGS:

Calendar 291
Engineers Meet to Discuss Restrictions on Automobiles 291

PERSONAL MENTION 292

*Illustrated Article

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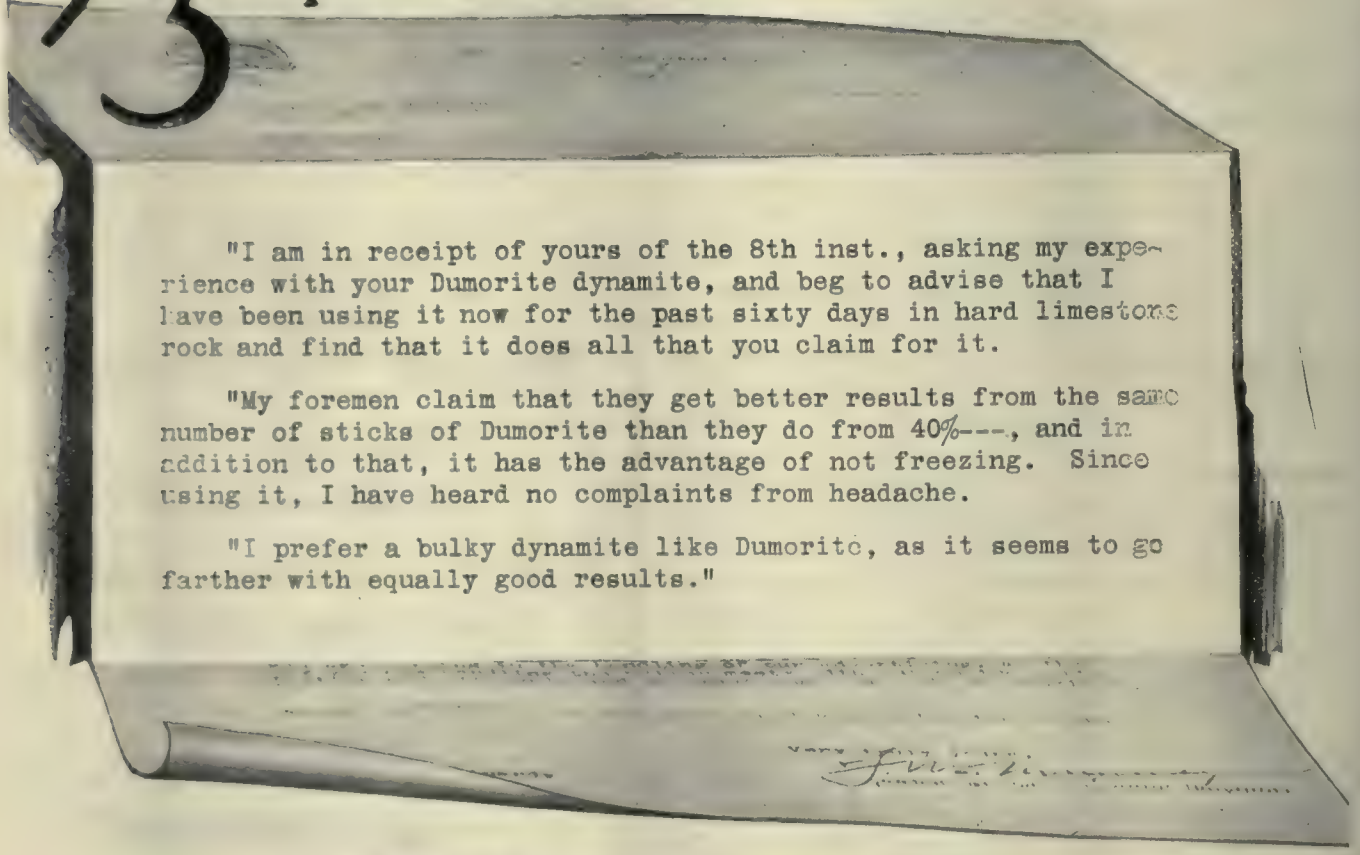

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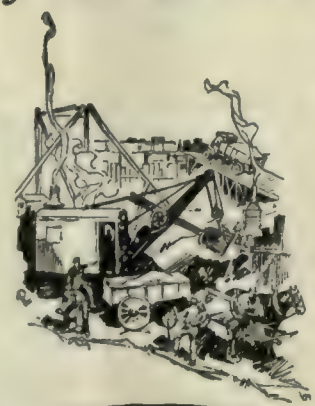

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GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

WITH WHICH IS INCORPORATED

THE HIGHWAY CONTRACTOR AND ROAD BUILDER

Vol. LXII. NEW YORK, N. Y., MAY 24, 1922 No. 21

The Bronx River Parkway Drive

Development of Bronx River Parkway Reservation and Construction of Parkway Drive—Beautiful Approach to New York City to be Completed in 1923

By L. G. HOLLERAN†

The Bronx River Parkway Reservation extends for for a distance of over 15 mi. from the Botanical Gardens of Bronx Park, in New York City, to the Kensico Dam, 4 mi. north of White Plains.

The reservation consists of a strip of land from 200 to 1,200 ft. in width, through which the Bronx River winds and turns on its way from the Westchester hills. The reservation extends through a thickly settled region for about two-thirds of its length, including within its boundaries portions of the northerly part of Bronx Borough, City of Mount Vernon, City of Yonkers, Villages of Bronxville, Tuckahoe and Scarsdale, and City of White Plains.

More than 25 years ago, in 1895, the polluted condition of the Bronx River attracted sufficient attention to bring about the appointment by the governor of an investigating commission. This commission recommended that a sanitary trunk sewer be built parallel to the river. The question of enclosing the entire river in a big storm sewer was discussed, but discarded, it being impracticable to build a storm sewer large enough to carry the flood waters. The commission's recommendation to expend a large sum for the construction of a sanitary sewer did not at that time appeal to the public imagination and nothing resulted therefrom.

Another investigating commission was appointed in 1906, which recommended that the most feasible solution, having regard for economy and return in public utility, was the creation of a parkway reservation, which would include the low lands and immediate slopes along either side of the river. The commission pointed out that this was the cheapest way to protect the river and that the land to be acquired would provide locations not only for a sanitary sewer, but also for a great parkway with a traffic artery extending from New York City's park system 15 mi. along this picturesque river to the magnificent Kensico dam and reservoir, where the City owns 4,500 acres of beautiful woodland and lake areas. These recommendations were adopted as a joint project of New York City and Westchester County, and the legislative act provided for acquiring about 1,200 acres of land along the river, elimination of sewage pollution and the development of a parkway.

†Deputy Chief Engineer, Bronx Parkway Commission.

SECTION AT WAKEFIELD BEFORE IMPROVEMENT

SAME SECTION AT WAKEFIELD AFTER IMPROVEMENT

Commissioners were appointed under this act by Governor Hughes in 1907, and in June, 1913, after some amendatory legislation had been passed, the first appropriations for the acquisition of lands were made available. About two-thirds of all lands were acquired by private purchase and the remainder were taken by condemnation. As rapidly as the land was acquired, the buildings were sold and removed, foundations filled up, pollution eliminated and the land and river made available for such use by the public as their undeveloped state would permit of. From 1916 to 1918, small appropriations were made available for construction work and since 1919 appropriations, which permitted a comprehensive construction program to be carried out have been made by the City of New York and Westchester County each year.

With these funds the development of the Parkway reservation has proceeded at such a rate that its practical completion is expected by the end of the year 1923.

Development of the Parkway Reservation

The Bronx River is the fundamental feature which controls the engineering and construction problems, the location of the Parkway drive, and to a large extent the physical improvement and landscape development of the reservation. The flooding of the marginal lands and low-lying sections of the reservation is typical of the problem offered by many rivers. To avert destruction of property and large losses, the conservancy district idea has been evolved and applied in other sections of the country, as, notably, on rivers in the Middle West.

Somewhat analogous is the Bronx River Parkway Reservation, which may be considered as a conservancy district on a small scale. The river flows through Bronx and Westchester Counties and through various municipalities. It would be quite useless to improve it in one section and neglect the others. It was, therefore, necessary to study it throughout its entire length, and one basic object of the work of river regulation was to prevent flood overflows.

Jurisdiction over the river throughout the entire length of the reservation enabled the commission to adopt comprehensive plans. The details of these plans vary with the topography of the different sections. Studies were made which enabled the commission to fix the proper profile for deepening the channel, so that when the river imrovement has been completed, the water will be held at nearly constant levels during the greater portion of the year.

The purely aesthetic element was also kept in mind. Natural slopes and banks were left undisturbed as far as practicable since straight slopes and a canalized channel would not in any sense be appropriate in park development. These river channel improvements will serve three purposes: first, the reclaiming of low lands by eliminating flood overflow; second, the securing of a sufficient depth of water for the development of swimming pools and water sports, and, third, the supplying of sufficient material for use in grading the parkway drive and marginal lands in order to provide the proper landscape development.

Design and Construction of the Parkway Drive

The main highways between the City of New York and Westchester County are already overcrowded on Sundays and holidays when most people desire to use them. The Bronx River Parkway Drive will form an additional outlet between the city and upper Westchester County which will tend to relieve congestion and provide a more direct route from the city to the watershed lands and highways leading into Connecticut and northern New York.

Having in mind the greatly increased traffic which has occurred during the past few years, the Commission fixed the width of the parkway drive at 40 ft., except in a few locations where it will be divided into two 20-ft. drives in order to take advantage of topographical conditions favorable to establishing two driveways instead of one. These widths will allow of two lines of traffic in each direction which, it is expected, will meet requirements for many years to come.

After the driveway is staked out, the topsoil is excavated by a dragline excavator, or by steam shovel, and usually piled along the shoulders of the driveway where it is afterwards used to cover the embankment slopes as they are completed. The river channel, or pool, from which the excavated material is to be obtained is then dredged by a dragline excavator and the excavated material deposited on the shore to dry for a few days. When sufficiently dry to handle readily, the material is loaded by steam shovel into horse-drawn dump wagons, or into dump trailers hauled by 10-ton Holt tractors, and deposited within the limits of the driveway embankment.

The soil encountered in the Bronx River valley varies greatly in different localities. In some localities a mixture of sand and gravel is encountered which provides excellent material for the driveway embankment. In other localities there are layers of fine sand alternating with layers of black clay and silt which would, if used alone, provide a very poor foundation. Where it is necessary to use such material, the driveway embankment is brought to a profile about 1 ft. below subgrade level and a layer of sand or cinders at least 1 ft. in depth is deposited on the poorer material to provide a well drained bed for the surface pavement.

In many localities the driveway is carried either along or at the foot of the slope of one or the other of the hillsides which form the river valley. Usually, on the up-hill side of the driveway and at other locations in the low lands where the ground water level is near the surface, porous tile under-drains laid in rock-filled trenches have been provided to take care of the

sub-drainage. Vitrified tile or concrete pipe drains to take care of surface drainage are placed at low points and at intermediate points on long grades.

In many instances the space between the river bank and the foot of the slope is so narrow that walls of some kind are required to retain the driveway embankment and protect it from scouring where it encroaches on the river channel. In order to eliminate the more formal concrete retaining walls, which are usually provided in such cases, the commission has made use of the large numbers of boulders and large rocks which abounded in certain portions of the reservation to provide a type of boulder riprap which is more in harmony with the general scheme of development than a formal concrete retaining wall would be.

For the driveway pavement, the commission has adopted a Portland cement concrete base with a bituminous wearing surface. Curbs approximately flush with the bituminous wearing surface are provided where the driveway is on fill and curbs three inches in height are provided where the driveway is in cut. The curb is constructed integral with the concrete foundation. To date two types of bituminous wearing surface have been placed. Asphalt blocks have been used on about 3 mi. of the driveway between Crane Road, Scarsdale, and Woodland Place, White Plains, and bituminous concrete has been used on about the same length between Duncomb Street, Williamsbridge, New York City and Mount Vernon Avenue, Yonkers.

In letting contracts for the paving, alternative bids are taken on various types of bituminous wearing surface. A schedule has been prepared and adopted by the Commission, after a thorough investigation by its Engineers, which fixes the relative value of the various types of bituminous wearing surfaces, and the type of pavement which will give the greatest value for the cost, as determined by the bids, is selected after the bids have been canvassed.

In designing the concrete foundation, the attempt was made to secure a slab with a base as near to the horizontal as possible without unduly increasing the thickness at the crown. The design finally adopted is 5 in. thick at the sides and 7 in. thick at the center. The finished pavement, which follows a parabolic curve in transverse section, has a crown of 5 in. in the width of 40 ft. This is considerably less than is generally used for a pavement of such width, but this crown provides satisfactory lateral drainage, even on flat grades, and allows the bottom of the concrete base to be formed by two straight lines from each side to the center of the roadway, which deviate from the horizontal by only 3 in. at the center.

Asphalt blocks 5x12x2 in. are laid on a 0.5 in. mortar bed with sanded joints. The bituminous wearing surface is laid 2.5 in. thick.

The asphalt block contract included 57,200 sq. yd. of pavement, while the bituminous concrete, which was let in two different contracts, but to the same contractor, included 70,000 sq. yd. These two stretches of pavement, which were placed by different contractors and by different methods, allowed a comparison to be made as to the relative efficiency and economy of the methods used.

Methods Employed on Asphalt Block Contract

On the asphalt block contract, the equipment for placing concrete base consisted of: two 17-cu. ft. capacity concrete mixers with gravity chutes and driven by

STONE FACED CONCRETE BRIDGE AT WHITE PLAINS

gasoline engines; three 1-cu. yd. truck tractors equipped with dump bodies; two bucket elevator loading machines, and two pumps for furnishing water for concrete.

Cement, sand and crushed stone were delivered to the job in 6-ton capacity motor trucks. The cement and crushed stone were shipped in barges, unloaded at the dock at Hastings-on-Hudson, and delivered to the driveway, with an average haul of 8 mi. The sand for the concrete was obtained about 2 mi. from the work where it was screened directly from the pit into automobile trucks having a capacity of 4 cu. yd., by means of a path-digging loader equipped with a screening device. This device consisted of a screen attached to the top of the loading machine with a power vibrator attachment. In screening, sand was deposited in the truck and particles over ¼-in. in size were diverted into a deflector chute at the bottom of the screen and deposited alongside the trucks.

After being transported to the job, the sand was stock-piled on the subgrade along one side of the road with spaces of 10 ft. between piles. The crushed stone was dumped on the opposite side of the road with spaces of 5 ft. between piles. The remainder of the roadway was left clear for the transportation of cement and other materials. Two concrete mixers were operated abreast, one on each side of the driveway, the concrete being placed in one operation for the full width of the pavement. Two bucket elevator loading machines were used in handling the crushed stone and sand. The stone was elevated from the stone piles by the loading ma-

chine to measuring bins having the capacity required for a one-bag batch, and the sand was handled in the same manner by the loading machine at the sand piles. The three-wheeled truck tractors delivered the crushed stone and sand to the loading skips of the concrete mixers. The truck tractors traveled up to the sand loader where the tractor operator opened a bin and received a charge of sand. He then drove to the stone loader and received a charge of stone. The mixture was then delivered at the mixer skip. Under ordinary conditions, three truck tractors were used at the mixers without appreciable congestion.

The following crew was engaged on the concrete foundation: 1 foreman, 2 mixer engineers, 3 tractor operators, 2 loading machine operators, 1 pump operator, 2 curb finishers, and 18 laborers. And for setting forms the following were used; 1 sub-foreman, and 6 laborers.

Steel forms held in place by wooden or iron pins were used in forming the flush or 3 in. curb and for retaining the concrete in the pavement section. With this equipment and organization, the average rate of construction per day was 300 lin. ft. of 40-ft. pavement. The average day's run was about 200 cu. yd. The maximum day's run was 260 cu. yd.

The equipment used in laying the asphalt blocks was as follows: 1 mortar mixer, 2 gravity block conveyors, 1 pump, 1 block cutter.

The organization for laying the asphalt blocks was as follows: 1 foreman, 8 block carriers, 3 block layers, 1 axeman who wedged the blocks to a good bearing, 1 block cutter, 1 broomer for brooming sand into the joints, and 2 men piling blocks; and for placing the mortar bed, 1 mixer operator, 1 bed maker, and 5 laborers.

The average day's run with this force was about 1,600 sq. yd. of finished pavement and the maximum day's run was about 1,800 sq. yd. of finished pavement.

Methods Employed on Bituminous Concrete Contract

On the bituminous concrete contract, the equipment for placing cement consisted of: 1 27-cu. ft. capacity concrete mixer with extension boom and bucket, 2 pumps, and 12 wheelbarrows; and the organization embraced: 1 foreman, 1 mixer engineer, 1 fireman, 31 laborers, 2 curb finishers and 1 team and driver. 1 subforeman and 6 laborers were engaged in setting forms, which were of steel construction held in place by steel pins.

The materials were piled along the driveway about as previously described for the asphalt block contract, and transported from the piles to the mixer skip in wheelbarrows.

The average day's run with this force was about 215 cu. yd. and the maximum day's run was about 245 cu. yd.

The latter organization with one concrete mixer, equipped with boom and bucket, and operating with wheelbarrows instead of truck tractors was, therefore, able to place a greater average yardage of concrete per day with less men than the organization with two concrete mixers equipped with chutes.

The organization for laying the bituminous concrete surface was as follows at the asphalt plant: 1 general foreman, 1 yard foreman, 1 engineer, 1 hoist runner, 2 trestlemen, 1 oiler, 1 blacksmith, 1 mixer foreman, 2 mixers, 5 stone feeders, 3 sand feeders, 1 dust feeder, 3 utility men, and at the driveway: 1 foreman 2 rollermen, 1 fireman, 5 rakers, 2 tampers, 15 shovelers. The equipment at the driveway consisted of: 1 8-ton roller, 1 10-ton roller, 1 fire wagon, 9 auto trucks, 2 heating tanks.

The average day's run for the above force was about 2,200 sq. yd. of finished pavement, and the maximum day's run was about 3,100 sq. yd. of finished pavement.

The bituminous concrete was mixed under what is sometimes known a sthe Topeka specification and consisted of asphaltic cement having a penetration of about 50, Dow method, at 77° F. mixed with trap rock screenings, sand and dust. It was mixed at a stationary plant located about 8 mi. from the center of the stretch of driveway on which the pavement was laid, in batches weighing 1,700 lbs. and transported to the job by 6-ton capacity motor trucks. On leaving the plant, the truck drivers received a ticket from the inspector showing the number of batches in the truck, time of departure, and temperature of the mix at the time of departure. The slip was taken up by the inspector at the pavement upon the arrival of the truck. A careful check of the bituminous concrete delivered and laid was made, at intervals during the day and at the end of each day's run, to compare the actual yardage laid with the theoretical equivalent as determined by test in accordance with the number of batches delivered.

The Two Types of Pavement Compared

The asphalt block pavement was placed in 1920, when prices for material and labor were at about their maximum, and the cost was $5.05 per sq. yd. of pavement. including the concrete base, flush and 3 in. curb, and the asphalt block wearing surface.

The bituminous concrete pavement was laid in 1921, when prices of material and labor had receded appreciably, and the cost per sq. yd. was $3.56, including concrete base, flush and 3 in. curb, and the bituminous concrete wearing surface.

The asphalt block pavement has now been in use about two years, and a portion of the bituminous concrete pavement has been in use for about one year. It is, of course, too early to form any definite opinion as to the actual comparative wearing qualities of the two types of wearing surface or of the stability of the pavement as a whole, but it may be said that to date no evidences of failure have appeared in any part of the 6.5 mi. of pavement constructed under these two

contracts, although all the pavement was laid on comparatively new embankments throughout its entire length.

Types of Bridges and Viaducts

It would have been possible to eliminate most of the winds and turns in the Bronx River within the limits of the Reservation so that very few driveway bridges would be required, but such a procedure would not only have been very expensive in the way of excavation and disposal of excavated material, but would also have practically destroyed the natural beauty of the river, and the valley through which it flows. In order to preserve the river as nearly as possible in its natural condition, it was necessary to locate the driveway in such a way that it crosses and re-crosses the river channel on driveway bridges a number of times.

The commission early recognized the importance of designing the driveway bridges so as to harmonize with the surroundings and fit into the general scheme of development. To no other type of structure required in the development of the parkway reservation has more attention been given than to the designing of these bridges. In all cases, competent architects have been employed to advise on the architectural design, and the results obtained through the co-operation of these architects with the commission's engineers have more than justified the adoption of this procedure. In general, the attempt has been made to produce arched structures. The earlier designs consist of a reinforced concrete arch with stone facing for the approach walls, arches and spandrels.

In order to reduce the quantities of excavation and concrete required for the abutments of a true arch bridge, a type of reinforced concrete beam and slab constuction masked by a native granite facing, including arch rings, approach walls, spandrels and parapets, was developed by the commission's designing force. This type of construction requires an abutment, or end wall, to support the beams of only 4 in. in thickness, with footings for the abutments only 6 in. in width for ordinary soil conditions. This design has proved to be not only very economical in cost, but to all intents and purposes the appearance is that of an arched bridge of stone construction.

In some localities the grade of the driveway at the river crossings is such that it would not be feasible to secure the rise necessary for an arched bridge without introducing an objectionable hump in the driveway profile. At these locations a reinforced concrete beam and slab bridge, similar to that described above, with a timber facing over the outside beams, and timber fence, has been designed. The plain concrete approach walls are faced with rubble or native stone. In these bridges an attempt was made to simulate old-time timber beam bridges. The oak fencing or guard rail was hewed and pinned together with oak pins and the woodwork stained to imitate weathered timber.

Four viaducts are required to carry existing or proposed streets over the parkway drive or to carry the parkway drive over the New York and Harlem R. R. tracks and the Bronx River. Two of these four viaducts have been constructed. In both instances the construction is of reinforced concrete without stone facing. The Broad Street viaduct spans the parkway drive, the Bronx River and the tracks of the New York & Harlem R. R. Company, and connects Broad Street in the City of Mt. Vernon with Broad Street in the City of Yonkers. This viaduct consists of six reinforced concrete arches varying in span from 85 to 94 ft. with appropriate approach walls. The earth filled spandrel wall type of construction was used.

At White Plains, the Woodland Place viaduct carries the parkway drive over the tracks of the New York and Harlem R. R. and the Bronx River. This viaduct has one arch of 145 ft. span and an overall length, including approach walls, of approximately 300 ft. The arch consists of four reinforced concrete ribs on which the roadway structure of slab and girder construction is carried by columns and spandrel arches.

At six of the main highway crossings, the parkway drive will be carried under the existing streets. These undercrossings will be located at: Gun Hill Road, Borough of The Bronx; Palmer Avenue, Pondfield Road and Tuckahoe Road, City of Yonkers; Ardsley Road, Scarsdale; and Main Street, White Plains. The intensity of the traffic to be expected on the parkway drive is such that within a short time after the opening of the completed driveway, grade crossings would have become so dangerous that undoubtedly an immediate demand for their elimination would have resulted. The commission, therefore, decided to eliminate grade crossings at these locations from the outset.

The structure which carries Gun Hill Road over the parkway drive was constructed by the City of New York under plans furnished by the Commission, but the remaining five undercrossing structures will be built by the Commission. Two of them are now under construction.

The Commission's designing engineer, Mr. Arthur G. Hayden, has worked out a type of undercrossing structure which, so far as is known, has never before been used under similar conditions. The design consists of a reinforced concrete frame having the appearance of a true arch. The footings are about 6 in. in width and support the side walls or abutments averaging about 4 in. in width. The slab or arch forming the roof apparently springs from these side walls or abutments, but the whole structure is tied together with reinforcing steel in such a manner as to form a frame rather than a true arch. As the span of the structure is about 41 ft. 6 in. and the rise had to be kept down to about 3 ft. 9 in. in order to secure headroom at the center of the driveway of at least 15 ft. and yet keep the pavement elevation above water level in the adjacent river, it can readily be seen that this form of construction is

very much more economical in the way of excavation and concrete than the ordinary arched structure with gravity abutments. It is estimated that the adoption of this form of construction allows of a saving in cost of about $5,000 for each structure. This design was adopted by the commission only after tests had been made on models and the computations checked by a firm of consulting engineers specializing in reinforced concrete design and construction. Full details of the design will be published in the technical journals shortly.

The Bronx Parkway Commission consists of Madison Grant, president; W. W. Niles, vice-president; and Frank H. Bethell, treasurer. Engineering and construction work is under the supervision of Jay Downer, engineer and secretary. Herman W. Merkel is consulting landscape architect.

GOOD ROADS AID FLOOD PREVENTION

Good roads have conquered the Mississippi River floods. Such a statement, in all truth, might be applied in the instance of the recent tremendous floods which have just swept down the Mississippi River to the Gulf of Mexico, because it was the facilities for quick transportation of men and materials that enabled the people of the lower Mississippi valley to repair weak places in the great levee systems which hem in the river and prevent overflows which would have inundated millions of acres of the country's richest farm lands.

"Our roads paid for themselves in this one fight," was the statement made to the congressional committee, which made a special inspection trip down the river the first week in May to get first hand evidence of the situation which exists when the Mississippi goes on a rampage.

"We never could have held the levees this time had it not been for our good roads," the party was informed. "In the old days when we got word of threatened breaks, it took hours to get men and materials to the scene. With our new improved highways, it was but a matter of minutes for us to reach vital points. We haven't had a break in the 1,000 miles of earthen walls between the mouth of the Ohio and Vicksburg, Miss."

There were numerous instances of threatened breaks. Men and materials were rushed to these points and repairs made. One of the most serious was at Old Town near Helena, Ark. Here, a secondary levee line 1,000 ft. long was constructed by volunteers in a few days' time. Had the job not been done quickly, the breach at Old Town would have caused a flood over an area of more than 1,000,000 acres. Phillips County, Ark., in which the breach was threatened, has some of the finest all-year roads in Arkansas. It has 52 mi. of asphaltic concrete and 61 mi. of concrete highways, supplemented by many miles of good gravel roads. When the call came for men and materials to save the levee, they came in trucks, cars, wagons, and all sorts of conveyances, and they came quickly. Their timely arrival unquestionably prevented a break that would have meant the loss of hundreds of thousands of dollars to the farmers of that region.

In the same manner, breaches were prevented at Stoops Landing, near Greenville, Miss.; at Tunica, Miss.; and at other points. It was possible to move quickly over fine roads. It was one of the striking features brought out before the informal meetings between the congressional party and the residents of the region, and it was a clinching argument for the continuation of the good roads program which has been in progress in the lower valley for the past four, or five years.

$2,000,000 FOR ROADS IN NEBRASKA

The State Department of Public Roads of Nebraska will let road contracts on June 12 which contemplates a total expenditure of approximately $1,750,000. This is the first letting to be held this year. Work now being done and already completed on contracts held over from last year will add about $300,000 to this amount and bring the total expenditures for 1922 to over $2,000,000. The road construction program embraces few very large projects. The largest is a 6 mi. stretch of pavement between Valley and the Dodge County line which is to cost $200,000. Another large project is the construction of 26 mi. of earth and gravel road in Lincoln County at a cost of $100,000. It is estimated that the cost of road construction will be 15 per cent. less than last season and that the work will be completed by November 1.

FOREST HIGHWAY PROJECTS APPROVED

The U. S. Department of Agriculture has just announced the approval by Secretary Wallace of the expenditure of $594,000 of the national forest highway funds for the construction and repair of forest roads in Nevada, South Dakota, and New Mexico. This money was made available for roads serving national forests and for roads within or adjacent to the forests, which are of primary importance to states, counties, or communities.

The amount approved for Nevada, $166,000 will be allotted to two roads in the Toiyabe National Forest in Lander County and one in the Nevada National Forest in White Pine County. South Dakota will spend $61,000 from the fund on one road, the Deadwood-Hot Springs Highway. The projects approved for New Mexico include 30 mi. of road in Taos County, 25 mi. in Catron and Grant Counties, and 9 mi. in Santa Fe and Miguel Counties and the amount to be expended is $367,000.

The Commission of Highways of North Carolina plans to award contracts on May 25 for the construction of 198 mi. of hard surface and top-soil roads in every district of the state. This will be the largest award ever made at one time by the commission.

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

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Copy for advertisements must reach the New York office by noon on Tuesday of the week before date of issue if proofs are to be submitted.

Copy for classified and other advertisements where proofs are not required will be accepted until noon on Monday of the week of issue.

Articles by road builders are solicited. They should be short and, if possible, accompanied by photographs. Those accepted will be paid for at current rates.

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IMPORTANCE OF HIGHWAY ENGINEERING

The Nevada Highway Department is publishing in "The Nevada Highway News" articles which seek to give the people of Nevada a clearer conception of the problems of highway location and design so that the layman will not think that money spent on surveys and preparation of plans is money wasted.

There is need of a great deal of such educational work among the people of this country. A great many have no clear idea as to what a highway engineer really does and are apt to belittle his work and look upon it as for the most part unnecessary. A clear understanding on the part of the taxpayer of the fact that accurate surveys and careful planning are necessary if the state is to have proper location, alignment, and drainage of its roads and the most economical construction costs, would not only make easier the work of the highway departments in promoting and financing road construction but would also place a greater importance upon the work of the engineer which would redound to his credit.

The taxpayer is generally pictured as a person who thinks only in terms of his pocketbook. He is apt to think that the highway engineers are doing work of little value and that the money spent on engineering is an unnecessary overhead charge in the construction of his highways. If he could be shown that lack of accurate surveys, detailed plans, and proper inspection would mean poor location, faulty design, and costly construction, would not the pendulum swing to the other extreme? Could he not be brought to see that, not engineering costs as such, but the attempt to be economical by paying small salaries to engineers and maintaining a small force, would mean money out of his pocket?

The problem of location and design of highways requires not only technical education but also knowledge of the economics of highway transportation and a keen insight into the future development of the country. Solving these problems is no task for makeshift organizations or incompetent employees. In short, the highway department is a very poor place for a state government to try to save money, and the taxpayer should be made to realize that fact.

The highway engineer has a "big job" and it is through education of the people to that effect that he will be able to take the place in the eyes of the public which the importance of his work warrants and to command a salary more in proportion to the salaries of business and professional men in other fields.

THE DUNN BILL SHOULD NOT PASS

Almost daily the number of state highway departments and organizations devoted to road building and highway transport that protest against the passage of the Dunn bill increases. This bill was introduced by Chairman Dunn of the House Roads Committee, has been passed by the House, and is now before the Ways and Means Committee of the Senate. It would amend the Federal Aid Act passed in 1921 and nearly all of the changes are found to be objectionable in some of the states. Particular objection is made throughout the country to the provision which would cut in half the limit of federal aid per mile of road constructed by the states.

There is still time for those who favor a continuation of the present highway policy to protest to their representatives in Congress against the passage of this bill.

TO LIMIT MOTOR TRUCK LOADS

The Massachusetts Highway Commission is seriously considering the reduction of the maximum motor truck load permissible on the highways of that state to 20,000 lbs. including truck and load. Such was the statement made by James W. Synan of the Massachusetts Highway Commission at the recent meeting of the National Highway Traffic Association. Mr. Synan said that an extensive plan of road building was under way in his state but, as it would take several years for the best type of roads to catch up with the existing highway transport conditions, it might be necessary to reduce the present legal weights until such time as the state roads could sustain the steadily increasing heavy traffic. The proposed limitation would prohibit the use of a motor truck exceeding five tons capacity. The motor interests of the country advocate the uniform adoption of a maximum load of 28,000 lbs.

GAS-TAR PROTECTS CONCRETE AGAINST ALKALINE WATERS

In its search for a means of protecting Portland cement concrete against the action of alkaline waters, the Bureau of Public Roads, announces promising results from treatment with a very fluid crude water-gas tar, such as may be obtained as a by-product from many artificial gas plants. So successful have the tests bee that further investigations of the alkali-resisting properties of tar-treated concrete and mortar are under way and the protective effect of water-gas tar on mass concrete structures is being studied.

The treatment consists of simply immersing the concrete in the liquid, which is soaked up, even by a dense concrete. Cement drain tile treated in this way and stored from six to eight months in a strong alkali solution have shown no indications of disintegration, and samples tested for tensile strength were as strong as those stored in pure water. On the other hand untreated samples showed both disintegration and a loss of strength.

In certain parts of the country where alkali salts exist concrete drain tile and concrete structures have been attacked. In many such places concrete is a very desirable material on account of the accessibility of the materials that go into it. The bureau's investigations aim to devise means of using concrete with assurance.

NEW DEVICE SETS STANDARD FOR SMOOTHNESS OF ROADS

How smooth should a contractor reasonably be expected to make the surface of a road? Engineers of the Bureau of Public Roads have devised an instrument for settling this question. When passed over the road it indicates that the slightest unevenness or roughness.

The instrument will be used to test the surface on different types of road of good workmanship, thus determining a standard which contractors can be held to. Smoothness in a road is, of course, desirable for the comfort of travelers, but it is also desirable for other equally important reasons, say officials of the bureau. The vertical movement of a motor vehicle caused by roughness wears the machine and requires more power of the engine.

In connection with experiments along this line another instrument has been devised. Attached to a vehicle this determines the amount of jolting or vertical movement caused by different degrees of roughness or uneveness in the surfacing.

TYPES OF HIGHWAYS IN NEW YORK

The 1921 annual report of the New York State Highway Commission shows that in general only two types of pavement were constructed in New York State, concrete and bituminous macadam. Other types were built to such slight extent as to be almost negligible. Of all the highways constructed in 1921, 56 per cent were of concrete and 44 per cent of bituminous macadam. In every instance, comparative estimates were made and the type of construction determined by study of the estimates in connection with a study of the local condition, available material, traffic conditions, importance of the highway, kind of soil, and the character of the country through which the road was to pass. When bituminous macadam was selected, it was usually of a thickness of approximately two and one-half times that of concrete.

CRUSHED STONE PRODUCTION INCREASES

The report of the U. S. Geological Survey on the production of stone in the United States in 1921 shows that, during a period of general depression in the industry, the revival of street construction in cities and villages created a great demand for paving blocks and increased the sale of curbing and flagging. At the same time, the campaign for the improvement of suburban and country roads caused an increase of nearly eight per cent. over 1920 in the output of crushed stone. Decreases were noted in the demand for stone for other purposes than road and street construction.

EUROPE TO AID MOTOR TOURISTS

Many long wanted changes in the regulations governing motor traffic on the highways of Europe will be made this summer as the result of the labors of the International Traffic Congress which has just concluded its session in Paris. The European countries aim to encourage the motor tourist by establishing uniform road regulations and by doing away with many of the vexations which have beset them in the past. The congress went on record as in favor of the total abolition o fpassports, one of the most important of these vexations.

ILLINOIS ANNOUNCES 1922 ROAD PROGRAM

A recent announcement from the office of Governor Small of Illinnois stated that 1,050 mi. of new paving would be constructed in 1922 at an approximate cost of $30,000,000. In addition to the 688 mi. already contracted for this year, 3622 mi. of paving are planned for and contracts will be let as soon as possible. Construction of this mileage will exhaust the $60,000,000 bond issue of 1919 as well as the federal aid allotment for Illinois. Besides the paving, the program calls for 122 mi. of grading.

The new Ohio River highway bridge between Ironton, Ohio, and Russell, Ky., which was recently dedicated, was constructed in 274 days. The bridge has a main span of 725 ft. and the whole structure is 1,425 ft. long between anchor piers. The bridge was built with private funds and will be operated as a toll bridge. The cost of the bridge was about $700,000.

MEETINGS

Calendar of Coming Meetings

May 26-27 — Dixie Highway Association — Annual convention, Jacksonville, Fla. Secretary, M. B. Roberts, 302 First National Bank Bldg., Chattanooga, Tenn.

June 4-6—American Association of Engineers—Annual convention, Salt Lake City, Utah. Secretary, C E. Drayer, Chicago, Ill.

June 12-15—Canadian Good Roads Association—Ninth annual convention, Victoria, B. C. Secretary-treasurer, George A. McNamee, Birks Bldg., Montreal, Canada.

June 26-July 1—American Society for Testing Materials—Twenty-fifth annual meeting, Atlantic City, N. J. Secretary, C. L. Warwick, Engineers' Club Bldg., Philadelphia, Pa.

Aug. 9-10—Custer Battlefield Highway Association—Annual meeting, Sheridan, Wyo. Secretary, W. D. Fisher, Sheridan, Wyo.

Oct. 9-13—American Society for Municipal Improvements—Annual convention, Cleveland, O. Secretary, Charles Carroll Brown, St. Petersburg, Fla.

ENGINEERS MEET TO DISCUSS RESTRICTIONS ON AUTOMOBILES

Equitable distribution of taxes for road construction and maintenance, including motor vehicle license fees, and desirable restrictions of size, weight, and speed of vehicles using the roads will be discussed by a committee of engineers which will meet at Washington, D. C. Participants in the conference will represent the Association of State Highway Officials, the U. S. Bureau of Public Roads, and the automotive industry.

Taxation and restrictions are, of course, legislative matters, the bureau points out, but any agreement reached between the national and state government officials and the automotive industry will have an important bearing on legislation.

The Burea of Public Roads estimates that $600,000,000 was spent for roads in 1921, derived from the following sources: local road bonds 33 per cent.; county, township, and district taxes, assessments, and appropriations 14 per cent; state taxes and appropriations 12 per cent; state road bonds 7 per cent; motor vehicle license revenues 19 per cent; federal aid 14 per cent; and miscellaneous sources 1 per cent.

Much light has been thrown upon the effect of weight, size, and speed of vehicles by recent impact tests, by observation of sections of experimental road tested to destruction by heavy traffic, and by traffic censuses which show the importance of motor transport to our commercial life. It is well established that there must be some limit to the loads which our highways are called upon to carry, says the bureau, but on the other hand the great service now rendered by motor transport and the far reaching possibilities of the future must not be unduly lessened by viewing only one side of the question. It is very desirable, the bureau believes, that the makers of motor vehicles and the builders of roads should get together on this matter. Development of roads and motor transportation have gone hand in hand in the past, each dependent on the other, and cooperation and mutual understanding is necessary for progress in the future.

CITY PLANNING SCHEME FOR NEW YORK CITY LAUNCHED

Questions of highway transport will play no small part in the city planning scheme recently launched by the trustees of the Sage Foundation at a meeting held at the Engineering Building in New York City. The scheme contemplates comprehensive and coordinated development of New York City and the surrounding territory within lines extending from the far end of Long Island, through Bridgeport, Conn., West Point, N. Y., and Trenton, N. J., to the coast. Generally speaking, the plan is to make the City of New York and the 300 cities, towns, and villages in the adjacent territory better places to live in and to work in. There are within the area 9,000,000 people and it was to announce the project to them publicly that the meeting was held. The advance work will be completed this fall and it is expected that in about two years a definite plan embracing all the essentials will be ready for presentation to the city authorities.

The North Dakota Highway Commission estimates that about $3,000,000 will be spent on federal aid projects in North Dakota this year. Of that sum, about $2,000,000 will be expended on new projects and about $1,000,000 on projects carried over from 1921.

The Supreme Court of the State of Wisconsin in a recent decision re-affirmed the right of the state railroad commission to assess against railway companies part of the expense of the elimination of dangerous grade crossings.

A bill has been introduced in Congress to provide for the return from Europe of motor-propelled vehicles and other equipment used by the American forces in Germany for distribution to the state highway departments, and for other purposes.

Personal Mention

Benton Anderson has been elected city engineer of Clinton, Ia.

Leslie H. Balknap, Deputy Commissioner of the Michigan State Highway Commission, has resigned and will be succeeded by G. C. Dillman, an engineer in the maintenance department.

H. P. Borden, sometime member of the Board of Engineers of the Quebec Bridge and former consulting engineer to the Department of Highways and Canals of the Canadian Government, has opened a consulting office in Ottawa.

Julius Brown, former assistant to County Engineer Davison of Waseco, Minn., has been appointed county engineer of Rock County, Minn.

Walfred Fregolie has been appointed village engineer of Hibbing, Minn.

R. H. Fletcher, Resident Engineer with the Montana State Highway Department, has resigned to become city engineer of Helena, Mont.

Henry A. Fulenwiter, of Wilmington, Del., has been appointed town engineer of New Castle, Del.

H. E. Hawkins, City Engineer of Eldorado, Kan., has been appointed city manager.

R. S. Hummel has been appointed chief of the bureau of street paving of the department of public works, Richmond, Va.

P. J. Hurtgen has been appointed city engineer of Kenosha, Wis., to succeed B. C. Brennan, resigned.

Fred W. Lang has been appointed city engineer of Concord, N. H. to succeed W. B. Howe who died April 3.

W. L. Lozier has been appointed engineer in charge of public improvements at Seneca Falls, N. Y.

James A. Mortland, Bridge Engineer of the Florida State Highway Department, has resigned to enter private practice.

C. E. Rice, City Engineer of Wooster, Ohio, has resigned.

George C. Stanley has been re-appointed city engineer of Burlington, Vt.

R. E. Stoelting, former city planning engineer of Milwaukee, Wis., has been installed as commissioner of public works to succeed Percy Braman.

C. G. Trowbridge, City Engineer and Superintendent of Construction of Decatur, Ga., has resigned to engage in engineering work with the St. Simons Island Investment Co.

J. C. Jones, County Engineer of Meade Co., Kansas, has resigned to enter private practice in Wisconsin.

John H. Dennis, formerly with the state highway department in Michigan, has been appointed county engineer of Genesee Co., Michigan.

Harvey Fuller, City Engineer of Chatham, Ont., has been appointed city manager. He will continue his duties as city engineer.

David B. Miller has been appointed city engineer of Michigan City, Ind., to succeed D. C. Ford, retired.

C. R. Tillotson, recently of Hutchinson, Kansas, has been appointed county engineer of Elk Co., Kansas, to succeed C. F. Osborn, retired.

The Daniel Webster Highway, which runs from the state line between Massachusetts and New Hampshire northward through the White Mountains, was recently dedicated at the boundary line where Tyngsboro, Mass., and Nashua, N. H., join, by officials of the two states. In view of the fact that Daniel Webster lived much of his life in Marshfield, Mass., there is a movement on foot to extend the Daniel Webster Memorial Highway southward to Boston and through Marshfield to Cape Cod.

The State Highway Commission of Pennsylvania has assured the American Legoin that all its engineers and superintendents have been directed in engaging employees to give first consideration, all other things being equal, to ex-service men.

The Automobile Club of America has appointed a committee of eighteen to promote the plan of marking highways by number which has been adopted by the New England States.

The U. S. Bureau of Public Roads has approved the final plans submitted by the Indiana State Highway Commission for the ideal section of the Lincoln Highway which is to be built in Lake Co., Indiana, this year.

The cost of road construction in Missouri has been so materially reduced within the last six months that it has almost reached the 1914 pre-war level.

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Vol. LXII May 31, 1922 Number 22

TABLE OF CONTENTS

*The Delaware River Bridge 295
Status of Highway Curves and Recommended Practise to Increase Safety of Traffic. By H. Eltinge Breed 298
Lincoln Highway in Nevada Assured 299
Railroad Freight Rates Reduced 299
Traffic Capacity and Widths of Highways Outside of Municipalities. By H. C. Smith 300
Forest Highway Construction Approved 302
No Verdict in Cement Case 302
Mark Highways with Color Bands 302
Bureau of Public Roads Gets Appropriation of $483,320 306
Wages for Road Work Reduced 306

EDITORIALS:

The Delaware River Bridge 301
A Stumbling Block 301

EQUIPMENT-TRADE-MATERIALS:

*Gasoline Engine Drives Road Grader 303
*Attach Troweller to Concrete Tamper 303
Asphalt Pavement Foundation 304
Bucyrus Company Enlarges Plants 304

MEETINGS:

Calendar 305
Canadian Good Roads Meeting 305
Texas Highway Association Adopts Platform and Budget 305
National Chamber of Commerce Holds Highway Session 306

PERSONAL MENTION 306

*Illustrated Article

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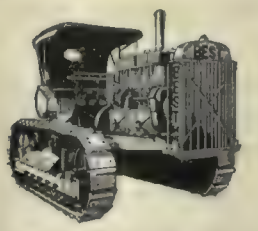

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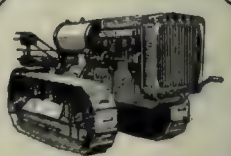

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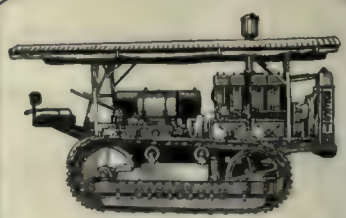

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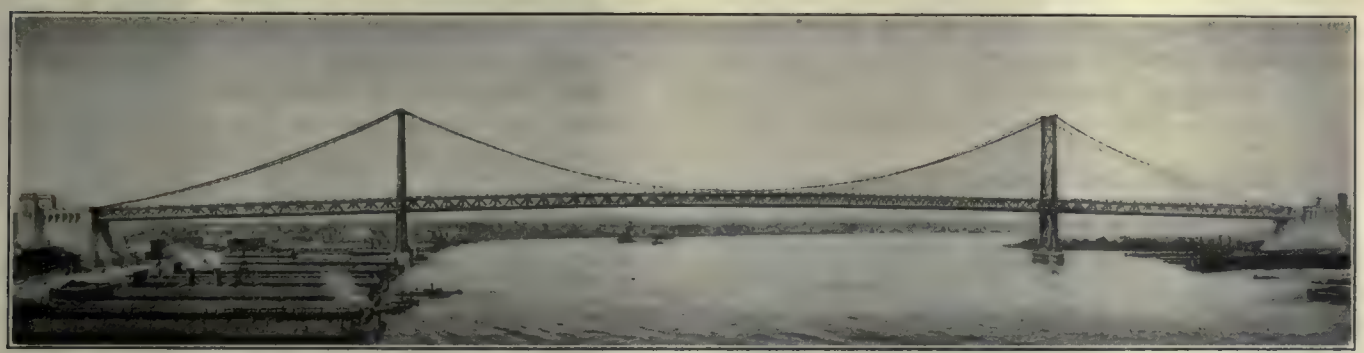
THE HIGHWAY CONTRACTOR AND ROAD BUILDER

Vol. LXII. NEW YORK, N. Y., MAY 31, 1922 No. 22



The Delaware River Bridge

Construction Under Way On Huge Structure Which Will Span the Delaware River Between Philadelphia, Pa., and Camden, N. J.—World's Longest Suspension Bridge to Be Completed in 1926

With appropriate ceremonies participated in by the governors of Pennsylvania and New Jersey, the Delaware Bridge Joint Commission, and the mayors of the two cities, work has been begun on the Philadelphia-Camden bridge. This bridge, which will span the Delaware River with a single span 1,750 ft. in length and will link two cities and two states, will be larger than any existing suspension bridge in the world. Starting in Philadelphia from a point on Sixth Street midway between Race and Vine Streets opposite Franklin Square, it will cross the river in a straight line to Pearl and Second Streets in Camden and hence curve southward to a point on Penn Street midway between Sixth and Seventh Streets. The cost of the structure is estimated at $28,871,000 and it will be completed in time for the Sesqui-Centennial in 1926.

Historical

The earliest record of a definite project to build a bridge across the Delaware River from Philadelphia to Camden was in 1818 when an application was made to the legislature of New Jersey and later to the legislature of Pennsylvania to build a bridge from the Camden shore to Windmill (Smith's) Island, a distance of 2,200 ft., leaving the remaining distance to the Pennsylvania shore to be covered by ferry. The plans for this bridge bore the name of its projectors and designers, Farrand and Sharpe.

There does not appear to have been any organized effort to secure a bridge over the Delaware River until the legislature of New Jersey, by an act passed in 1914, provided for the appointment of a commission with "power to construct one or more bridges or tunnels under or over a navigable stream or river which is the boundary of the state." This commission was not fully organized until 1916. It made a report in 1918 which suggested a bridge and advised against a tunnel.

In December, 1914, Council of the City of Philadelphia by resolution requested the chief engineer of the Bureau of Surveys to report on the feasibility of erecting a bridge between that city and Camden. He reported in December 1915 that the project was perfectly feasible from an engineering standpoint and, in February 1916, an ordinance was passed creating a commission to investigate further into the matter.

This commission was superseded by a Pennsylvania State Commission of three members authorized by an act of legislature in July 1917.

By acts of the legislature of New Jersey in 1918, the Interstate Bridge and Tunnel Commission was created as a new body and authorized to proceed with the construction of bridges and tunnels as extensions of the state highway system. This commission joined with the Pennylvania commission and engaged Dr. Warren P. Laird, Consuling Architect, ot make

studies and report upon a location for a bridge over the Delaware River. He reported in November, 1918, and recommended what is known as the Washington Square-Federal Street site.

In 1919, the legislature of Pennsylvania and New Jersey passed uniform laws which created the present Delaware River Bridge Joint Commission with full authority to proceed with the construction of the bridge. This commission in September 1920 engaged a board of engineers composed of Ralph Modjeski, Chairman, George S. Webster, and Laurence A. Ball. After careful study of the character of foundations, conditions of traffic, land values and costs at the most favorable site, the board of engineers presented their report in June, 1921. This report recommended the Franklin Square-Pearl Street location and gave general plans and estimates for the structure, and is the basis for the construction now under way.

Men Who Are Creating the Bridge

The Delaware River Bridge Joint Commission is made up of the following men: Pennsylvania, Governor William G. Sproul, Chairman; Mayor J. Hampton Moore of Philadelphia; State Treasurer Charles A. Snyder, Auditor General Samuel S. Lewis, Thomas B. Smith, Richard Weglein, Samuel A. Vauclain, Thomas J. Jeffries, New Jersey; T. Albeus Adams, Thomas J. S. Barlow, Theodore Boettger, John F. Boyle, Frank F. Gallaher, Weller H. Noyes, Samuel M. Shay, Charles S. Stevens; legal counsel, Robert S. Gawthop, Fred Taylor Pusey, David J. Smyth, Joseph Costello, Secretary; Charles R. Bacon, Assistant Secretary; Edward I. Edwards, Jr., Treasurer; John F. Whitaker, Assistant Treasurer.

The board of engineers retained Leon S. Moiseiff as consulting designing engineer and made the following appointments: Paul P. Cret, Architect; Arnold W. Brunner, Consulting Architect; Clement C. Chase, Principal Assistant Engineer; E. B. Bergendahl, Chief Draftsman and Assistant Engineer, and M. B. Case, Principal Construction Engineer.

Credit should also be given to U. S. Senator Edge, former Governor of New Jersey, who helped maintain state and national endorsement of the bridge and to Representative Darrow of Pennsylvania who cooperated with Senator Edge.

Location

The act of Congress which granted authority for the construction of the bridge defined the limits of location as Greene Street, Philadelphia, on the north and South Street on the south to points approximately opposite in Camden. Within this zone, there are no natural features on either side of the river that obviously determine the location. A free hand was, therefore, given to the selection of the most advantageous site.

The considerations which moved the board in selecting the site took into account the fact that the bridge connecting the two states should be a proper and logical extension of the state highway systems and also that it is to be a direct link between the inter-related communities on the opposite banks. The site was chosen, then, to attain a careful balancing of the ends and to serve the best interests of all the communities concerned. The bridge will serve all classes of vehicular and passenger traffic and a compromise had to be made to their different demands and desired routes of travel, as well as provision for the increase in traffic in the future. Besides convenience of use, the cost of construction at various locations had to be considered and attention given to foundation conditions, required length of span and approaches, and necessary disturbance of existing structures and interference with business.

Special studies of the cross-river traffic served to emphasize the convenience of the Franklin Square-Pearl Street site to the majority of those who will use the bridge and test borings and development of design showed the advantage in the economy of construction.

The Franklin Square plaza is two blocks north of Market Street and within easy walking distance of the shopping and business district of Philadelphia and is adapted to the existing transportation system and planned and authorized extensions of rapid transit. It is as close to the origin and destination of vehicular traffic as it is possible to locate an approach. Distribution is possible by direct routes to all parts of the city and over its boundaries. These routes are ample both as to number and direction they take. The widening of some streets is planned in connection with the plaza and approach to the bridge.

On the New Jersey side, the approach will give distribution of vehicular traffic at a plaza convenient to the actual focusing point of the state highways and will not involve forcing through traffic into Camden's business streets or on a long detour. A boulevard is planned from the bridge to the Court House and other improvements to make the approach beautiful and dignified as well as convenient for traffic. A loop line of bridge cars is proposed which will make connection with the present New Jersey traction system and the Pennsylvania Railroad at its Broadway station.

Design

The bridge, as planned, is a two-cabled suspension type. The distance between the pier heads is 1,690 ft. With main piers 60 ft. wide, the main span is 1,750 ft. The span of the Brooklyn bridge is 1,796 ft. and the span of the Williamsburg bridge is 4 ft. longer, so that the Delaware River bridge marks a decided advance in length of span, surpassing by 150 ft. the longest suspension bridge in the world. The distance between the anchorages is 3, 189 ft. The overhead clearance is 135 ft. above mean high water.

The Warren trusses were adopted for the approaches to harmonize with the main span construction. The

spans range in length from 132 to 192 ft., most of them being 160 ft. The trusses are placed 95 ft. center to center. One track is carried on the inside and one on the outside of each truss. The trusses and footwalks above them follow the gradient of the transit tracks for which a maximum grade of 5.22 per cent was decided upon. The roadway is on a lighter grade not in excess of 3.5 per cent. Where the approaches are near ground level, the roadway and tracks are carried on earth fill between concrete retaining walls of gravity section. These walls will be faced with granite and topped with a granite balustrade. The roadway on both the approaches is widened from the 57-ft. width of the main span to 63 ft.

A live load of 12,000 lb. per lin. ft. was used to cover the condition of absolute maximum congested traffic and all parts of the bridge designed to withstand the resulting stresses. The dead load was figured from information as to the weight of similar structures and streets and sections of members computed on that basis. The roadway floor was designed to carry at any point a moving load of 30 tons. Wind loading was considered to cause a pressure of 50 lb. per sq. in. of exposed area. Temperature stresses were compiled for a variation of 55 degrees above and below normal temperature.

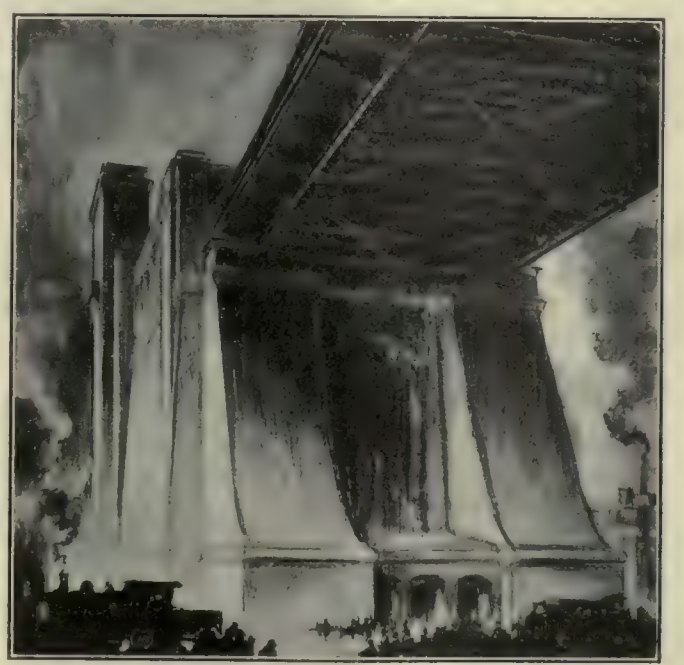
The dimension which has the most important bearing on the economy of design of a suspension bridge is that of sag, or versed sine, given the cables. This dimension is the vertical distance between the highest point of the cable curve at the towers and its lowest point at mid-span. This distance is 200 ft.

This large versed sine results in the towers attaining a heighth of about 380 ft. above the water line. The tower legs have a width parallel to the cables of 12 ft. at the top widening to 40 ft. at the base. Transversely, the width is 7 ft. for all points above the floor level. The towers are of steel construction.

The anchorages are of masonry designed as a monolith. Each anchorage will require 90,700 cu. yd. of masonry and will rest on gravel strata and on inclined caissons extending down to rock or other satisfactory material. The horizontal pull of the cables combined with the weight of the anchorage produces a resultant inclined to the vertical about 1 ft. in 6 ft. It is intended to sink 20 small caissons to hard foundations with the same inclination as the resultant of the forces. To give access to and from the river for passengers, elevator shafts with an ultimate capacity of four passenger elevators were provided in each anchorage. The anchorages are the principal architectural features of the design and their treatment is based on the principle of expressing the constructive features and achieving a decorative effect by an outline of the greatest simplicity.

The suspension bridges over the East River in New York are of four cable design. The choice of a two cable design for the Delaware River bridge requires an increase in cable diameter from 20.5 in., on the Manhattan bridge, to 30 in. Despite this increase, the manufacture and erection of the cables involves no new or untried procedure. Each wire of the 16,500 composing each cable is approximately the same diameter as previously used and can be put in place by methods and with apparatus similar to that used with smaller cable. The single wires are 0.192 in. in diameter and are placed individually and parallel to make 61 strands which are bound together and wrapped with serving wire to make up the completed cable. Every 20.5 ft. measured horizontally, a circumferential cast steel saddle is fastened to the cable over which four galvanized wire ropes, 2⅝ in. diameter each, are hung to carry the suspended structure. The cables rest on cast steel saddles on the towers and at the anchorages. Back of the anchorage saddles they are fastened to anchor chains and imbedded in the mass of anchorage masonry.

The function of the stiffening trusses is to distribute,



WEST ANCHORAGE AT PHILADELPHIA

more or less uniformly, the discontinuous and concentrated live loads that come upon the bridge. The dead load of the trusses themselves and the floor system is carried by the main cables. It is good design to select trusses of rigidity sufficient for the character of travel without employing too much material. Therefore a high strength steel is used. Depth of truss is 28 ft. and the panel length is 20.5 ft. for the main span and 20.75 ft. for the side spans.

The short panels of the stiffening trusses result in an economical and simple floor system. All roadway and track stringers are rolled beams. The tracks are carried on steel ties and the roadway paving on reinforced concrete slabs with adequate provision for expansion and contraction.

The roadway is 57 ft. wide from curb to curb to take care of six lines of traffic. The bridge also carries two lines of surface car tracks and two lines of rapid transit tracks on the main deck. Above there are two 10-ft. sidewalks. The total width is 125 ft. 6 in. as compared to 123 ft. for the Manhattan bridge and 86 ft. for the Brooklyn bridge.

Materials

All main truss members, towers, floor beams, and some bracing will be of high strength alloy steel. A medium carbon steel will be used for the remaining steel construction except the cables and hangers of the suspension design. For them, high carbon steel wire possessing even greater strength than that used in the New York bridges will be available. All exposed masonry construction will be of granite with backing or cores of concrete. Reinforced concrete will be utilized for the roadway slab and for certain structural elements in the approach subways and anchorages. The roadway will be paved with wood block.

Cost

The cost of the structure, estimated at $28,871,000. will be shared by New Jersey, Pennsylvania, and the City of Philadelphia. The apportionment is as follows: New Jersey, $12,429,000; Pennsylvania, $8,221,000; Philadelphia, $8,221,000.

The construction will go hand in hand with the great exposition planned for 1926 and the bridge will be completed by July 4 of that year, the Sesqui-Centennial of the Declaration of Independence.

Status of Highway Curves and Recommended Practise to Increase Safety of Traffic

By H. ELTINGE BREED†

The importance of safety on the highway, considered more or less vaguely by all those interested in highway traffic, becomes tangible through definite figures. There are now registered in the United States 10,500,000 motor vehicles. This year's increase to that number is estimated by manufacturers at 1,800,000. The risk to safety lies in the congestion of 90 per cent of these vehicles upon 10 per cent of our roads. This risk we must minimize. That it is at present fraught with appalling loss of human life is evidenced by the casualties from automotive vehicle accidents, a loss yearly greater than is incurred by all other means of transportation combined.

The majority of these accidents of congestion occur under five conditions, all of which roadbuilders may help to eliminate:

1. Sight distance on curves, both horizontal and vertical, which is insufficient to permit precaution against the other man's reckless driving. Lack of sight distance also increases the accidents at intersecting roads and at railroad crossings.

2. Insufficient width of pavement, especially in congested districts, which increases the number of cars that turn turtle on soft shoulders and hurtle down unprotected slopes.

3. The inadequate, irregular, and improper spacing of danger signs which encourages a general carelessness of their import. Judged by the number of accidents in their vicinity, they are a spur to the recklessness of the joy rider and a consequent risk to his sober brethren.

4. The tendency of detours under traffic to become almost impassable. On heavy-travelled routes, traffic going in different directions should be routed over different detours or if detours are inadvisable on account of dangerous or impassable conditions, the road should be built horizontally a half at a time.

5. Railroad grade crossings.

To help prevent accidents to which these and other highway conditions are conducive, we may proceed at four points; first, to secure good design for new roads; second, to promote adequate improvement of old roads; third, to insist upon reconstruction of existing roads at places that have proven especially dangerous such as grade crossings; fourh, to improve the location of the center line on dangerous curves and elevations. Under these headings the following recommendations are made. They aim to promote the saftey of the traveling public as far as impersonal factors can do it, and they aim to diminish as far as possible the personal menace projected by the reckless driver.

First of all, under the consideration of general safety for traffic, comes the necessity of standard practice throughout the counry in respect to placement of danger signals, elevation and banking of curves, widening and regulation of traffic on curves.

Standarization in these matters is imperative because, with the completion of transcontinental routes, there is increasing interstate traffic. Drivers traveling to remote sections cannot be evpected to apprehend distinctions in practice now existing between different highway departments; yet departure in one state from what they have become accustomed to expect in others is a frequent cause of disaster. There is no real obstacle in the way of this standardization. It is merely a matter of agreement among state highway officials and motor organizations.

Therefore, your committee proposes that you discuss,

*Committee report presented at annual meeting of the National Highway Tfaffic Association in New York, May 12 1922.

†Consulting Highway Engineer of New York City.

alter and finally recommend for standard practice the following resolutions in respect to general safety of highway traffic and to special precautions on curves:

First, that on all curves of more than three degrees the pavement and inner half of the earth shoulder be banked. This super-elevation should vary from zero for a three-degree curve, to 1 in. per ft. of width for curves of twenty degrees or sharper.

Second, that on all curves of more than four degrees the pavement be widened on the inside 0.5 ft. for each one degree increase in curvature.

The widening and banking on a four-degree curve should start at a minimum of 50 ft. before reaching the P. C. and come to the fully widened and banked section at, or very soon after, reaching the P. C. Inversely, the regular section should be reached at a minimum of 50 ft. beyond the P. T. For a twenty-degree curve, this varying or transitional width should be about 150 ft. long, with proportional lengths for intermediate curvatures.

Third, that a line about four inches in width of appropriate color be painted on the center line of pavement on all curves, this painted line to be renewed as necessary in order to keep it conspicuous and that it may indicate to traffic in each direction the limit of its half width of pavement.

Fourth, that all sharp or dangerous curves either simple or reverse, horizontal or vertical, should be posted about 500 ft. fom each end with a sign indicating that danger exists and the direction of curvature. Railroad crossings at grade should be posted in a similar manner.

Fifth, that the National Highway Traffic Association recommend to all legislative committees preparing motor traffic laws that the attempt to pass a motor vehicle while going in the same direction on a curve, either horizontal or vertical, where the unobstructed line of vision is less than 500 feet be made a misdemeanor and that all damages resulting from an accident under these circumstances be placed upon the passer.

Sixth, that the minimum radius of curves be 300 ft. unless prevented by an approach to a bridge not practicable to change, or the improvement being on a village or city street; even to the end that new right of way should be procured in order to increase the radius, bearing in mind that the improvement is being made for a long time, and that land values may increase to an extent prohibitive to procuring more right of way.

Seventh, that providing there is sufficient space within the right of way earth slopes be carried out with a 4 to 1 slope. If this is not possible, guide rail should be placed on the inner edge of all curves of more than eight degrees. This rail should be kept painted white and be about 4 ft. in height.

Eighth, that in order to prevent the shoulders adjacent to hard surfaced pavements from being gouged out, gravel or crushed stone (No. 1½ and No. 2½ size mixed and filled with screenings) should be placed 2 ft in width and 4 in. in depth on each side, maintained at the level of the pavement. An application of hot tar or asphalt on this gravel or stone will be found beneficial.

Ninth, that all advertising and other signs and obstructions along highway routes be eliminated except those erected by direction or permission of officials having jurisdiction over the highways and for public benefit.

Tenth, that a definite sum be set aside annually by each highway department, and a comprehensive plan devised on which annual progress is made, for the elimination of the most dangerous grade crossings.

There are also suggestions and projects for the future that your committee would like to offer as a sort of progress report for your comment and opinion.

We believe that, to minimize danger, the proper highway officials in each community should make a survey of the bridges in that community and determine to what extent, if any, they have to be strenghened in order to assure adequate support toincreasing traffic. At present, some of us are in daily fear of disaster to heavy motor buses laden with humanity.

We believe that many congested routes should be widened as an economic and satisfactory method to safeguard traffic.

We question whether the increased security to the public and saving of time would not justify the cost of grade separations for traffic at intersecting crossings on heavily congested routes approaching large cities.

These suggetions are debatable. Are they sufficiently valuable to be accepted as hypotheses to be proven by experimentation?

LINCOLN HIGHWAY IN NEVADA ASSURED

Contracts for the improvement of the Lincoln Highway across Nevada involving an expenditure of $1,500,000 have been approved by the Nevada Highway Commission and the attorney general of the state and have been signed by the president of the Lincoln Highway Association. These contracts involve $100,000 of the funds of that association which were required to assist the State of Nevada in meeting the federal aid as provided in the Highway Act of 1921. In consideration of this contribution, the state has undertaken to bring to completion before June, 1924, all the poor sections between the Utah line and Reno.

RAILROAD FREIGHT RATES REDUCED

Under a decision of the Interstate Commerce Commission announced May 24, railroad freight rates will be reduced on July 1 by amounts equal to 10 per cent of their present levels. Practically all classes of commodities are affected by the decision which is the result of an investigation into the reasonableness of the existing freight levels begun by the commission last autumn.

Traffic Capacity and Widths of Highways Outside of Municipalities*

By H. C. SMITH†

There has been a large quantity of statistical data compiled throughout the country in the nature of traffic census and many traffic studios have been made to determine the future traffic for given highways. Most of such data is not of maximum value, however, in determining the desirable width of roadways for a given traffic, in as much as the variation in speeds of various classes of vehicles generally is not given consideration. Any computation of required width of roadway based upon the assumption that all the traffic on a given highway outside of a municipality will travel at a common speed should be used with great reserve, as the assumption is obviously incorrect in all but exceptional cases.

For the greater part, highways outside of municipalities need have but two lanes to care for the traffic which they are called upon to accommodate. Highways leading into large municipalities, or connecting nearby cities, however, present a problem that calls for careful solution in as much as they may, and often do, carry traffic that varies in speed from about 3 mi. per hour to 35 mi. per hour. In many cases, the quantity of traffic approaches, and often exceeds, the economical traffic capacity of a two lane roadway, although computations may show that the amount of traffic anticipated from traffic surveys could be carried adequately by a two lane roadway if the traffic is assumed to travel at a common uniform and properly selected speed.

In cases of highways which are to carry congested traffic, the designing engineer must give careful consideration to all functions of a roadway which should affect his decision in choosng the number of lanes of traffic to be required and the modifications of widths of roadways and shoulders for any given number of lanes. The functions of a roadway which thus affect the design of its width are enumerated as follows:

1. To provide a sufficient number of lanes to carry the traffic that comes upon it.

2. To provide means of allowing fast moving vehicles to pass vehicles moving more slowly, the speeds being within legal and operating limits.

3. To provide for the ranking of vehicles at the roadside in such cases as for necessary temporary repairs.

4. To be of such a width as to discourage the taking of dangerous chances by operation of vehicles.

When a two lane roadway has become so congested that it is impossible to operate a vehicle without considerable loss of time due to traffic delay, its economic traffic capacity has been exceeded. This degree of congestion occurs for a traffic count of a great deal less than that equal to the computed traffic capacity of the roadway when variation in speed is not considered. As the amount of traffic or speed variations increase, the possibility of passing a slowly moving vehicle when it is overtaken becomes less. Ultimately, it becomes entirely impossible for vehicles to pass each other and all traffic must assume the speed of the slowest moving vehicle.

To emphasize the relation that should exist between traffic and roadway widths, the results of office computations and field observations of traffic operation made by the chairman of the committee may be of interest.

For one typical series of investigations for a two lane roadway, a traffic of 750 vehicles per hour was assumed, 500 of which traveled in one direction, the remainder traveling in opposite direction. Three assumptions as to variation in speeds were made.

First: 3 per cent were assumed to travel at 3 mi. per hour, 10 per cent. at 10 mi. per hour, 57 per cent. at 20 mi. per hour and 30 per cent. at 30 mi. per hour.

Second: 13 per cent. were assumed to travel at 10 mi. per hour, 57 per cent. at 20 mi. per hour and 30 per cent. at 30 mi. per hour.

Third: 13 per cent. were assumed to travel at 10 mi. per hour and 87 per cent. at 20 mi. per hour.

It was found under the first assumption that the meeting of two of the three-mile-per-hour vehicles slowed down traffic each way along the road for a distance of one-quarter mile. The meeting of vehicles of various faster speeds affected the movement of traffic similarly but to a less degree. It was also evident that 750 vehicles per hour, two-thirds of which is traveling in one direction and under the first outlined assumption as to variation in speeds, could not be operated on a two line roadway.

Under the second assumption of speeds, the meeting of two slow vehicles affected the traffic for a distance each way along the road of 300 ft., and the operation of the traffic under this assumption was entirely possible.

Under the third assumption, the traffic was shown to operate smoothly and the quantity could have been considerably increased.

The results of these computations were checked by observing the operation of traffic on roadways leading into Detroit, and the observed effect of varying speeds checked the calculations quite closely.

The foregoing results should be compared with computations based upon the assumption that all vehi-

(Continued on page 302)

*Committee report presented at the annual meeting of the National Highway Traffic Association.

†Assistant Professor of Highway Engineering and Highway Transport, University of Michigan.

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

Founded January, 1892

E. L. POWERS
Editor

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NEW YORK, N. Y.

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Copy for classified and other advertisements where proofs are not required will be accepted until noon on Monday of the week of issue.

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Vol. LXII. May 31, 1922 Number 22

THE DELAWARE RIVER BRIDGE

In 1883, the first suspension bridge over the East River between New York and Brooklyn was opened to traffic and hailed as one of the wonders of the world Nearly 50 years have elapsed since the Brooklyn bridge was planned and designed, and during that period only one bridge, the Williamsburg, has exceeded it in length of span. Now work has been begun on a suspension bridge which surpasses the Brooklyn bridge in length of span by 154 feet. That increase in length marks the development in suspension bridge design over a period of 50 years. In designing the Delaware River bridge, the engineers have been able to benefit by 50 years experience in the construction and use of suspension bridges.

A comparison of the slow development in design and construction of suspension bridges with rapid progress in design and construction of modern hard surface highways showed a marked contrast. The highway engineer has no such basis for his calculations as the bridge engineer. The work of constructing paved highways has been in progress a comparatively short time and so rapid has been the changes in the types of traffic accommodated that past experience is of little value to him. Lacking experience over a period of years, the highway engineer must turn to research and experimentation for his information.

He must also combat the present tendency of automobile owners and laymen in general to tell him what kind of roads he shall build. While no comparison of the relative engineering skill needed to design a suspension bridge and a highway is intended, the latter is just as much a special field as the former and there is no reason to suppose that any engineer or any user of the highways can solve the probblem of caring for the increase in motor traffic.

The designers of the Delaware River bridge counted heavily on past experience. No fear is entertained that the bridge which they have designed will not be safe or will not be adequate for the traffic now and for many years to come. The highway engineer who designs the state highways which connect with this bridge, having no such fund of experience to draw on, must turn to study of the problems of transportation and scientific research if he is to build roads of the same dependability.

A STUMBLING BLOCK

The Pennsylvania Highway Department has put a stumbling block in the way of the advance toward a system of uniform highway signs with an announcement that it will mark the main routes of the state wih color bands. The system of marking highways with numbers, which has been worked out by the Automobile Club of America and is similar to systems in use in the West, has been adopted by the New England states as the first zone. It was hoped that New York, New Jersey, and Pennsylvania would become the second zone. Commissioner Sisson of the New York State Highway Department has stated that he is ready to adopt the new system as he is convinced that the color band markings have been a failure. Now comes Pennsylvania with announcement of the adoption of a plan which has been tried and found wanting in a neighboring state.

The stumbling block may only be temporary, however, because the color bands do not last long and the highway department of Pennsylvania may be convinced of the superiority of the new system by the time they have to be renewed. In the meantime, it seems likely that New York will adopt the system of marking with numbers regardless of the actions of New Jersey and Pennsylvania. The real regret is that the State of Pennsylvania should spend a large sum of money in marking with color bands, which are of doubtful value to the tourists, at this time when the delay of a few months might have shown the advisability of marking with numbers.

The Nevada State Highway Department has received new contracts from the Lincoln Highway Association which cover funds originally made available to the department in 1919 for the improvement of certain sections of the Lincoln Highway in Nevada. These contracts include certain of the old ones, which had expired December 31, 1921, and several new projects and the total funds available amount to $100,000.

CAPACITY AND WIDTHS OF HIGHWAYS OUTSIDE OF MUNICIPALITIES

(Continued from page 300)

cles will travel at a common speed. Under logical assumptions as to clearance between vehicles, and assuming that all vehicles will travel 15 miles per hour, a two lane roadway should carry about 2,600 vehicles per hour in each direction. If the speed is reduced to 3 mi. per hour by a few heavy horse-drawn vehicles, the capacity is reduced to about 750 vehicles per hour in each direction. There can be no doubt, therefore, that the variation in speeds affect the traffic capacity and hence the required width of a roadway.

Quite obviously, a stalled car which, through inadequacy of shoulder design, is prevented from pulling to one side and hence blocks one lane of traffic, has the same or a worse effect on the traffic capacity of a roadway than a slow moving vehicle. The roadway traffic capacity can be materially increased by adequate width and design of shoulders.

The safety of traffic should not be disregarded in the design of roadway widths. In the case of a two or four lane roadway, every vehicle operator realizes just when he has the right of way and when he has not. The operation of a three lane roadway, however, is not so simple. The center lane is not and cannot be reserved for traffic in either direction, so it must be left to each individual operator to decide whether he is more entitled to this lane than another operator going in the opposite direction. Such a width of design fosters danger to traffic.

Your committee respectively submits the following tentative conclusions for consideration:

1. The design of roadway widths must give consideration to the economically desirable variation in speeds of the various classes of traffic.

2. Any two lane roadway carrying intensive traffic should have a width of 20 ft. and should have 5 ft. shoulders capable of sustaining standing vehicles for temporary delays.

3. A two lane roadway should be increased to a four lane roadway when the traffic is reduced to the speed of the slower vehicles through not being able to pass, if the economic loss of time will justify the expense.

4. The building of three lane roadways should be discouraged due to the danger to the traveling public.

FOREST HIGHWAY CONSTRUCTION APPROVED

Expenditures totaling $2,038,472 of national forest highway funds have just been approved by Secretary of Agriculture Wallace for the construction of forest roads in California, Utah, Washington and Wyoming. This sum is distributed as follows: California, $968,697; Utah, $280,700; Washington, $575,000; Wyoming, $214,075. Wyoming will build the greatest mileage, 90 mi., California and Washington will build 50 mi. each, and Utah will build 57 mi.

DON'T DROP LIGHTED CIGARS ON WOODEN FLOOR BRIDGES

Don't throw away your cigar or cigarette when crossing a bridge with a wooden floor, advises the Bureau of Public Roads. It may start a fire that will destroy the bridge.

Many such fires are started. Most of them are put out with small damage, but occasionally a large structure is destroyed. It seems strange that a steel bridge should be destroyed by fire, but heat from a burning floor may cause the destruction of the whole bridge by softening; the breaking of one weakened member will cause the whole span to drop into the river. On some large bridges a watchman is kept to guard against this danger, and in a dry season fires have been known to occur almost daily.

A committee composed of a representative of the bureau and representative of the National Board of Fire Underwriters, the lumber and creosote industry, and the Engineering News-Record is now investigating the subject and considering the best means of protection.

NO VERDICT IN CEMENT CASE

The jury in the case of the government against 19 corporations and 44 individuals engaged in the manufacture of cement who were charged with violating the Sherman anti-trust law was unable to agree on a verdict and has been dismissed by Judge Knox of the United States District Court of New York City. On learning of his failure to reach a verdict, Col. Hayward, United States Attorney, said that the cases would be brought to trial again as soon as a federal judge could be found to hear them.

MARKS HIGHWAYS WITH COLOR BANDS

The State Highway Department of Pennsylvania will soon begin the marking of certain routes on the main highways of that state with color bands. In this route marking, three colors will be used: blue, red, and yellow. The blue routes will cross the state from north to south; the red routes from east to west; and the yellow routes diagonally. The highway department now whitewashes to a height of 6 ft. all poles on the highway routes. The new markings will be 12 in. in height and will be placed only at cross roads. On those poles marked with color bands, the whitewash will be only 5 ft. in height, the color band making up the balance of 6 ft.

The Kansas Highway Commission recently awarded contracts for the construction of 26.5 mi. of concrete pavement at a total cost of $721,957. The project is the largest yet undertaken by that state.

Ernest Solway, originator of the Solway process for the manufacture of soda, reputed to be Belgium's richest man, died suddenly at his home in Brussels on May 26.

Equipment — Trade — Materials

GASOLINE ENGINE DRIVES ROAD GRADER

The Motor Hi-way Patrol manufactured by the Russell Grader Manufacturing Co., combines a Russell grader and an Allis-Chalmers tractor unit. Both grader and tractor are operated by one man and the machine does the work of three teams and their drivers.

THE MOTOR HI-WAY PATROL

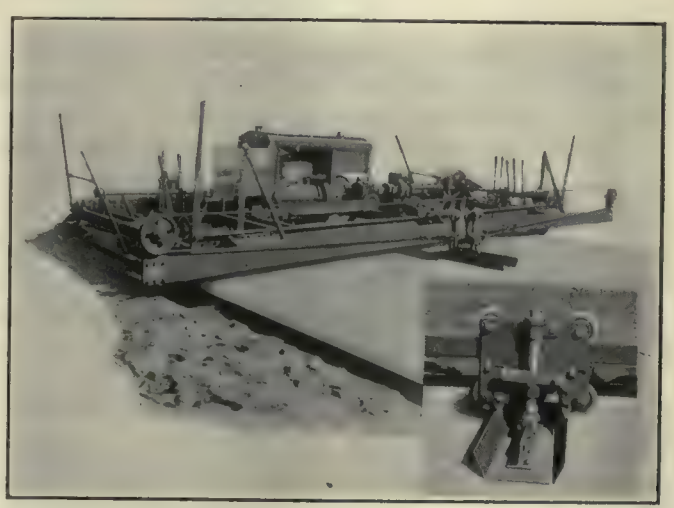
The 4-cylinder, 12 h.p. gasolene motor drives machine at a road speed of from 1½ to 3 mi. per hour. The centrifugal governor, which controls the motor at varying loads at a constant speed, can be adjusted to do so from the driver's seat at any speed between 500 and 1,000 r.p.m. A foot pedal operates the clutch and brake and a lever controls the gear shift. The method of steering, the entire tractor is pivoted on its axis by means of a segment and rack pinion, makes the tractor exceedingly easy to handle. The differential and transmission housings and the engine are bolted direct to the central shaft which carries the drive wheel axle and this construction gives strength, simplicity, and easy access to the units.

The grader has a 6 ft. blade 13½ in. wide. with detachable cutting edge The blade is raised and lowered by worm and gear which gives speedy accurate adjustment and automatically locks when in any position. The entire machine weighs 4,275 lbs., is 184 in. long and 6 ft. high, has a wheel base of 144 in. and a tread (grader wheels) of 5 ft. 2 in., and takes up about the same space in turning as an automobile.

The U. S. Geological Survey announces that there were 9,243,000 barrels of Portland cement produced during April, compared with 8,651,000 barrels during taled 8,592,000 barrels, as against 7,919,000 barrels last year.

ATTACH TROWELLER TO CONCRETE TAMPER

The Austin Machinery Corporation has announced, as a new feature of their concrete tamper, a troweller finisher which duplicates mechanically the old process of hand trowelling and improves on the old method in many ways.



TROWELLER ATTACHED TO AUSTIN TAMPER

The carriage, accurately made and fitting the adjustable profile bar, a templet of the exact crown of road required, travels across the road with a razor-stropping motion, at speed greater than that of hand trowelling. Two steel adjustable plows, one on each side of the 24-in. trowel proper, press down and work the surplus material. Easily controlled by two levers, a vertical lift is provided for the profile bar, and the stroke is made adjustable, so that it is possible either to trowel the full width of the road or work at any particular spot. At the back of the carriage is a mechanism which slightly tilts the trowel up in the direction of travel.

The net result of the troweller is to provide in the final finish a perfectly contoured road, swept by a trowel guided with mechanical accuracy for its entire stroke by a profile bar. No more dependance upon the human eye or effort to maintain a faultless grade. Furthermore, it provides a means for resurfacing any spots that may from any cause be disturbed by lack of sufficient concrete, footprints, or foreign material.

The T. L. Smith Co. of Milwaukee, Wis., has issued an illustrated catalogue of 29 pages descriptive of Smith pavers.

The best tracklayer sixty tractor is the subject of a 32 page illustrated catalogue issued by the C. L. Best Gas Traction Co., San Leandro, Cal.

ASPHALT PAVEMENT FOUNDATION

As the result of its extensive and successful use by state, cities, and other localities throughout the country, the employment of asphaltic foundation among highway builders is growing widely. The success attained by the State of California with black base, as well as the fact that C.M. Pinckney, Chief Engineer, Bureau of Highways, Borough of Manhattan, New York City, has adopted asphalt foundation in New York City's pavements, has attracted more attention to this type of foundation. Providence, R. I., has employed black base for both sheet asphalt and granite block construction, and North Carolina, in its plans for an extensive program of highway construction, is considering the use of a sand-asphalt type of construction in localities where stone is scarce

The use of asphalt foundation by the above mentioned places in addition to many other states and municipalities, has been discussed at recent meetings of highway engineering societies, and these discussions have brought out many points in favor of asphaltic foundadation for various types of pavement. The principal qualities of an asphaltic concrete or asphalt macadam structure which combine to make them such excellent pavement foundations are their intrinsic strength, flexibility, elasticity and imperviousness to water.

Experiments conducted by the U. S. Bureau of Public Roads have proved that impact, rather than dead load, is the destructive factor on our highways. It is in its efficiency in resisting the forces of impact that the asphalt foundation is superor to the rigid types. Because of its flexibility, an asphalt base tends to retain its contact with the subgrade under the pavement and to utilize the supporting power of the subgrade by passing on to it most of the impact received from traffic. A rigid foundation on the other hand is unable to retain contact with the subgrade, and is in many cases called upon to bridge over fallen sections and forced to withstand, itself, the total impact of traffic.

Flexibility is an important factor in the great economy attendant to asphalt base construction. It has been determined by actual service tests that under identical traffic and subsoil conditions the same degree of service is rendered by an asphalt foundation as is rendered by a rigid foundation of greater thickness, making the asphalt base a more profitable investment.

One of the most shortcomings of a rigid pavement or foundation is its inability to cope with the strain of expansion and contraction incident to temperature changes. Inevitably, the rigid slab cracks, and is left open to disintegration by traffic and water. A characteristic of the asphalt foundation, which lends greatly to its superiority over the other types, is its ability to withstand the expansion and contraction due to temperature changes. Consequently the damage caused by the stress and strain in the rigid type with varying temperatures, is eliminated, and cracking or other damage from this source does not have to be considered.

When a sheet asphalt or asphaltic concrete top is laid over an asphaltic foundation, the entire structure is firmly knit together and the base and wearing surface act as a unit under the action of traffic and temperature.

The presence of moisture in a pavement structure is both to be feared and guarded against. It is in this connnection that an asphaltic foundation has a great advantage. In their relation to moisture, asphalt and cement concrete have shown exactly opposite tendencies. The cement concrete structure will absorb moisture from the subgrade under a pavement by capillary action, and consequently, very often, a film of moisture is present on the cement concrete between the base and the top course. Obviously this film of moisture would be detrimental to the proper functioning of a pavement, and under certain conditios would hasten disintegration.

The above are the outstanding features of an asphalt pavement foundation. In addition, it is desirable for the ease with which it may be repaired. The time needed to cure other types of foundations before the top may be laid is eliminated because an asphaltic base is ready for the top as soon as it has been rolled, providing a rapidity of turnover and saving of labor to the contractor not possible in the case of rigid foundations. These, then, are some of the reasons why asphalt foundations have been laid so extensively in the west, and why they might be laid profitably throughout the country.

BUCYRUS COMPANY ENLARGES PLANTS

The Bucyrus Company, South Milwaukee, Wisconsin, have under way at the present time, extensive enlargements to both its plants at South Milwaukee, Wisconsin and Evansville, Indiana.

In the South Milwaukee plant, where all the larger machinery is built, a new gray iron foundry is now under construction, 276 ft. in length.

The old gray iron foundry is being converted into a cleaning room with annealing ovens, sand blast rooms, and a welding room. A large addition is also being made to the steel foundry moulding floor, and and electric furnace is being installed. Extensive improvements are also being made in the foundry storage yards. In the plant at Evansville, Indiana, which specializes in the manufacture of small revolving shovels, the machine and erecting shops are being considerably enlarged to enable the company to handle its rapidly increasing business in these machines.

The State of Alabama was the sixth state in the Union in point of highway construction started in April according to a statement of the highway department. During that month contracts were executed for road work to cost about $1,500,000.

MEETINGS

Calendar of Coming Meetings

June 4-6—American Association of Engineers—Annual convention, Salt Lake City, Utah. Secretary, C. E. Drayer, Chicago, Ill.

June 12-15—Canadian Good Roads Association—Ninth annual convention, Victoria, B. C. Secretary-treasurer, George A. McNamee, Birks Bldg., Montreal, Canada.

June 26-July 1—American Society for Testing Materials—Twenty-fifth annual meeting, Atlantic City, N. J. Secretary, C. L. Warwick, Engineers' Club Bldg., Philadelphia, Pa.

Aug. 9-10—Custer Battlefield Highway Association—Annual meeting, Sheridan, Wyo. Secretary, W. D. Fisher, Sheridan, Wyo.

CANADIAN GOOD ROADS MEETING

The program of the ninth convention of the Canadian Good Roads Association to be held at Victoria, B. C., June 12 to 15 has been announced. The annual meeting of the association will take place on the afternoon of June 13. The other sessions will be devoted to addresses, the reading of papers, and discussion of the topics presented. The subjects to be discussed cover widely all the various phases of road construction and highway transport and are to be presented by an imposing list of speakers both from Canada and the United States.

Speakers from the United States include: C. W. Cornell of Seattle, Wash., National Automobile Chamber of Commerce; Lt. Col. H. L. Bowlby, U. S. Bureau of Public Roads; H. D. Cuthbert, North West Pacific Tourist Association; N. D. Darlington, Chairman of the California Highway Commission; James Allen, Supervisor of State Highways, Olympia, Wash.; A. B. Fletcher, State Engineer, Sacramento, Cal.; Hon. J. P. Hartman of Seattle, Wash.; A. R. Hirst, State Highway Engineer of Wisconsin; and Windsor T. White, National Automobile Chamber of Commerce, New York. In addition to this formidable list A. P. Sandles of Columbus, Ohio, who was one of the outstanding figures at the Winnipeg convention, is expected to attend and give a practical talk.

Canadian speakers include premiers and cabinet ministers of the various provinces, representatives of provincial good roads associations, and highway engineers and officials from all over the country. The executives of the association have planned an elaborate program because they feel that the delegates will have traveled a long distance and are therefore entitled to gather all the information possible on highway matters and they are determined not to curtail it in any way.

TEXAS HIGHWAY ASSOCIATION ADOPTS PLATFORM AND BUDGET

The Board of Directors of the Texas Highway Association met in Waco, May 13, to perfect the organization of this newly formed body which was created at the annual convention of the Texas Road Builders Association, April 17.

W. T. Wheeler, Assistant Manager of the West Texas Chamber of Commerce, was elected secretary-treasurer and S. Deane Wasson, a newspaper man now connected with the Houston Chronicle, was elected publicity man.

A budget of $50,000 for the year 1922 was adopted and divided as follows:

Salary of secretary-treasurer	$6,000
Expenses of secretary-treasurer	3,000
Salary of publicity man	3,600
Expenses of publicity man	1,400
Office expenses of secretary-treasurer	3,000
Publicity, advertising, printing, posters, postage, etc.	20,000
Public speakers' expenses	10,000
Fair and exposition exhibits	1,000
Moving pictures	2,000
	$50,000

To outline the activities of the association, the board adopted a platform which states that the main object shall be the construction and maintenance of a connected comprehensive system of highways throughout the State of Texas. A elaborations of this dominating purpose, the plan the formation of district, county and local organizations to keep the state body in close touch with actual conditions; a survey of the present condition of the highway system; a study of the work of the state highway department with a view to correcting incorrect practices and expenditures; an investigation of all constitutional and statutory provisions relating to public highways, with special reference to necessary changes in the laws of Texas to bring them in harmony with the highway administration of the federal government; a complete investigation of highway financing with the object of determining the amount of money necessary and advisable to be raised annually and the best sources of taxation.

The money for running this organization will be raised among its members. Active members will pay dues amounting to $2.00 each year but the main sup-

port will come from the sustaining members who will pay $10,000 a year and no limit has been placed on the number of sustaining memberships one person or firm can subscribe for.

NATIONAL CHAMBER OF COMMERCE HOLDS HIGHWAY SESSION

A meeting devoted to the discussion of highway transport was held in Washington, D. C., May 16, under the auspices of the transportation department of the U. S. Chamber of Commerce in connection with the annual convention of that body. Thomas H. MacDonald, Chief of the U. S. Bureau of Public Roads, spoke on "Economic Foundation for Future Highway Progress," and E. J. Mehren, Editor of the Engineering News-Record, read a paper on "Practical Highway Transport Regulation." The reading of these papers was followed by a discussion of the topics presented.

BUREAU OF PUBLIC ROADS GETS APPROPRIATION OF $483,320

The appropriation bill for the Department of Agriculture for the fiscal year beginning July 1 has been passed by Congress and approved by the President. It makes available for the Bureau of Public Roads $483,320 of which $367,120 is for research and $116,200 for administration. The appropriations include: $66,800 for investigation of road management and construction; $77,060 for investigation of best methods of road building; $175,000 for investigation of chemical and physical character of road materials; and $15,000 for maintenance and repair of experimental highways.

WAGES FOR ROAD WORK REDUCED

The wage schedule recently adopted by the Minnesota State Highway Department shows decreases averaging about 15 per cent and is expected to total $250,000 for the season. The new rates are in line with those being paid by counties throughout the state and by private employers. Patrolmen will receive 55 ct. to 60 ct. an hour as compared with 65 ct. to 75 ct. in 1921. This includes pay for one team and rental of equipment. Laborers will receive 25 to 30 ct. an hour as compared with 30 to 40 ct. in 1921. For teams the pay is 25 ct. an hour as compared with 30 to 40 ct. in 1921. Truck drivers will receive 40 ct. as compared with 50 ct. in 1921; foremen $150 a month, a reduction from $175; grader operators $120 a month, a reduction from $135: and tractor operators $140 a month, a reduction from $160.

At the request of Secretary of Commerce Herbert Hoover, the American Engineering Standards Committee will undertake at once a survey of simplification or standardization needs and possibilities which will extend into almost every industry in America.

PERSONAL MENTION

W. H. Davis has been appointed maintenance engineer, West Virginia State Road Commission, with headquarters at Clarksburg, W. Va.

Stephen Kearney, City Engineer of Lowell, Mass., has resigned.

W. E. La Noue has resigned as city engineer of Victoria, Texas, and E. R. Thomas, formerly City Engineer of Port Arthur, Tex., has been appointed as his successor.

S. C. Liggett has been appointed assistant district engineer for the Virginia State Highway Commission with headquarters at Staunton, Va.

C. A. Myhre, formerly Division Engineer of the North Dakota State Highway Commission has been promoted to the office of project engineer.

B. H. Piepmeier, Road Engineer of the Illinois Division of Highways, has been appointed chief engineer of the Missouri State Highway Department to succeed Alexander Graham, resigned.

James R. Pollock, Assistant City Engineer of Flint, Mich., has resigned.

F. A. Reimer, C. E., has accepted the position of district engineer of the New Jersey branch of the Asphalt Association and has opened offices at 40 Clinton St., Newark, N. J.

F. H. Richardson, Assistant Engineer, Washington State Highway Department, has resigned to become field engineer with the Portland Cement Association wih headquarters at Spokane, Wash.

F. W. Ullius, Jr., formerly Village Engineer of Shorewood, Wis., has been appointed city planning engineer of Milwaukee, Wis., to succeed R. E. Stoelting, recently appointed commissioner of public works.

The City of Chicago has plans prepared and will ask for bids immediately for the widening of Michigan Avenue from Roosevelt Road south to 33rd St. It is estimated that the work will cost about $500,000.

The U. S. Civil Service Commission will hold an open competitive examination on June 21 to fill vacancies in the U. S. Bureau of Public Roads as follows: Junior civil engineer at $1,200 a year, junior highway bridge engineer at $1,200 to $1,600 a year.

GOOD ROADS

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TABLE OF CONTENTS

*An Economic Foundation for Future Highway Progress. By Thomas H. MacDonald . . . 307
Recent Developments in Highway Research . . 314
Wide Discretion Urged in Regulating Road Traffic 320
Location of Rural Mail Boxes 320
11,017 Miles of Roads Built with Federal Aid Since 1916 320

EDITORIALS:

The Compromise on Highway Legislation . . 313
Volume and Weight 313

MEETINGS:

Calendar 318
Confer on Traffic Signal Colors 318
To Hold Hearing on Highway Material Specifications 318
Road Makers Confer with Motor Manufacturers . 319
New Automobile Association Formed . . . 319
Invitation to First Meeting of Construction Council 319
Would Regulate Size, Weight and Speed of Motor Trucks 319

PERSONAL MENTION 320

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Glastonbury-Hartford Road, Glastonbury, Conn. "Tarvia-X," 1915

State Road at Kittery, Me. "Tarvia-X," 1912

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GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

WITH WHICH IS INCORPORATED

THE HIGHWAY CONTRACTOR AND ROAD BUILDER

Vol. LXII. NEW YORK, N. Y., JUNE 7, 1922 No. 23

An Economic Foundation for Future Highway Progress*

By THOMAS H. MacDONALD†

It would be trite to the verge of mediocrity in opening the discussion of this subject before such an audience, to assert the great need of building the nation-wide development of highway transportation now going forward upon enduring economic principles. were the facts existing at this time of lesser import. A great building lifts its parapets high above its surroundings, and hundreds of people spend their working hours within, untroubled by the thought that their safety depends upon the foundation courses extending to the supporting rock many stories below the pavements. A great bridge casts its spans across a mighty river—an architectural and engineering triumph wrought from the materials of construction—yet only is it secure and enduring as are the foundations which reach out of sight far beneath the surface to the earth's stratum which offers unchanging support. These things we accept almost as a matter of course, believing that such large undertakings have, as a prerequisite, undergone searching study and investigation to determine all of the factors which may exert an unfavorable or destroying influence, and that all of these have been properly guarded against in the design and construction adopted.

It is possible to comprehend something of the physical and financial undertaking involved in the completion of a great building or a great bridge, because each may be, as an entity, encompassed within the range of vision; but who can picture to himself adequately the immensity of the highway improvement demands which are now being made within the United States, to say nothing of those of the territorial possessions? No other nation has ever undertaken to supply adequate transportation facilities to an area of over 3,000,000 square miles. France has an area of 212,654 square miles, Germany 208,780, while the borders of Texas alone enclose 262,398 square miles. Our States are empires in their extent, and the whole future of this nation will be largely modified and determined by the factor of transportation including in this sense all forms of interchange. What is true of the nation is equally true of the individual.

It would seem, therefore, that the following general statements should be given full weight in this discussion. First, there are no precedents from which we may accurately estimate the total cost of providing the necessary improved highways, but the financial aspects even now are so large as to demand the most careful and scientific policies which may be determined. As the costs accumulate from year to year the increasing demands upon the financial foundation will cause failure unless the government policies are properly determined and planned for that future.

Second, no reason can be offered not to plan well for the future, for we are yet near the beginning of highway building activity in its major sense. There are not the same uncertainties that confronted the railroad builders. The early railroads were built largely on the strength of prospective and to an extent problematic traffic. The highways are being built for a traffic already waiting.

Third, there are plenty of evidences that the taxpaying public is rapidly nearing the end of its ability or at least of its willingness to act further in the capacity of a shock absorber. Too many public enterprises have been saved from bankruptcy only by calling on the public treasuries for additional funds to wipe out the deficit between estimates and cost, between income and outgo. There is no reason why the highways should not be placed in the self-supporting class. They are not a luxury nor an incidental, but one of the indispensable facilities to the life in all phases of the nation and of the individual. The highways are possessed of a real earning capacity, and this must be recognized, collected, and credited to them.

There is difficulty in properly allocating the earnings of the highway between the different services which it

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performs. But this may be accomplished acceptably by fair and impartial study and investigation. Up to the present too many such studies have been made for the purpose of proving a pre-determined conclusion. The old adage to the effect that it is the exception that proves the rule might well have been founded upon the conditions existing in the highway transportation field. There are many contradictions which arise when an attempt is made to apply general statements to specific conditions. All the aspects of highway improvement are so modified by the particular and specific conditions of the locality, small or large, under consideration, that he who is wise will not make either general or dogmatic assertions predicated upon insufficient or circumscribed data. Many of these assertions which we have accepted as almost axiomatic, fall down as soon as examined in the light of real fact. For example, it has been accepted as a to-be-rigorously-observed tenet that highway bonds shall be issued for a shorter period than the life of the road. The Cumberland Pike, the first and only great national highway of the early days, was thrown open to traffic about 1818. Today, after a full century, that highway is still in existence, rehabilitated and carrying an ever-increasing traffic. It is true that, due to the changes in overland transportation, there was a long period when this highway fell into disuse and disrepair, but today, with the surfacing repaired and rebuilt, the same road bed and most of the same waterway structures are continuing to carry the traffic. The extension of this road from Baltimore to Cumberland, originally a state project, was resurfaced in recent years at a very nominal cost. This light surfacing was placed for horse-drawn vehicular traffic, but with continued maintenance, and from time to time necessary reconstruction, is now carrying heavy automobile traffic. Under the theory just mentioned, for how long a period would the bonds, had the road been so built, have been proper? Apparently the road is in better condition today than ever before.

Again, suppose that capital is borrowed to establish a business. The earnings are sufficient to pay the interest on the original investment, and also for the maintenance, enlargements and betterments of the plant. Its earning capacity grows larger, its physical condition improves. The original buildings may be worn out and the original machinery discarded, yet the physical value of the plant as a whole is greater than the value of the original plant, and its earnings are increasing annually. Is it an evidence of unsound financing that the owner has continued to carry the original investment, using his earnings to maintain and increase the value of the plant by enlargements and betterments?

The term "permanent roads" is a fallacy which is responsible for more or less of the unsound theory which has been advanced with reference to bond issues. There are certain of the essentials of road construction, such as the road bed and drainage structures, that can be so built that the deterioration is so slow that they may be properly termed "permanent." Road surfaces of whatever type deteriorate. Maintenance should begin as soon as the surface is thrown open to traffic, and the higher the cost of the road, the more careful in detail should be the maintenance.

There is also the fallacy of the imposition of detailed and arbitrary legal limitations upon the character and weight of the loads which shall use the roads. Proper regulation within certain reasonable legal limits of the use of the roads is an administrative matter and should be so regarded. Even in a single state conditions vary to the extent that loadings which may be carried without deterioration of some road surfaces will inflict untold damage upon others. Yet under the average regulatory law which has been thus far made effective, the utility of the best roadways is not realized in the full, nor the safety of the lesser capacity roadways assured. Research in the field of the weight of loads that can be carried by different road surfaces is revealing very definite information. The influence of subgrade soils, of tire equipment, of the distribution of the loads to the wheels, of the speed and many other variables is too complex to be written into law. The seasonal variation alone in the carrying capacity of the road beds, due to moisture conditions, is one of the most serious of all the causes of road damage, and for this single reason the highway authorities must be given wide discretion in traffic regulation.

There is also the fundamental fallacy that has not yet been properly answered that federal aid for highway buildings partakes of the nature of a contribution from the richer states to those of lesser wealth, and that under the present distribution of federal aid some states suffer while others gain. Such a conception is altogether ill-founded. The only real question within the whole matter was settled by the adoption of the policy of federal participation in highway improvement. The income of the federal government comes almost wholly from three sources—internal revenues, postal receipts and customs revenues. The miscellaneous receipts and revenues from other sources constitute a very small percentage of the total. All of these major revenues are of a character which cannot be properly confined or allocated by states. The fact that these revenues are collected within certain states is not indicative of the source or production of the basic wealth which makes them possible. Likewise, many of the expenditures which absorb the greater percentage of the federal income cannot be allocated by states, such as the expenditures for the legislative, judicial and executive branches of the government, the maintenance of the Army and Navy, and other expenditures of a general nature. But the expenditures which can be allocated, such as those for postal service, public buildings, rivers and harbors, reclamation, pensions, highway building, all vary between the states as necessity demands, but the distribution of these expenditures among the states shows very closely the same percentage scale as the collection of the federal

income. The whole matter becomes one of the best division of federal income between the different activities which the government has undertaken as federal responsibilities.

There are many other fallacies which must be cleared away before we can hope to reach sound conclusions as to far-reaching permanent highway policies which will justify themselves over a long term of years. Our total expenditures for all highway purposes in the United States last year were approximately $600,000,000. This is the maximum expenditure for any year, but even this rate will not satisfy within any reasonable period the demand for improved roads. In the development of rail transportation the building of the road bed precedes the establishment of the rolling stock. In the development of highway transportation the individuals composing the public have equipped themselves with rolling stock to the extent of more than 10,000,000 motor vehicles, to say nothing of the large numbers of horse-drawn vehicles in use, and the public as a whole has charged itself with the task of providing the road bed. An examination of the progress in highway building over the past ten or twelve years indicates a very serious lag in the development of the road bed in comparison to the increase in the rolling stock. This lag is so serious that there is an insistent demand on the part of the very large body of owners that the providing of improved road beds shall be hastened. This demand in turn is followed, and properly so, because of the very large expenditures required, by the equally insistent question of who shall pay. There can be no question as to the service that highways render to the owner of the motor vehicle privately operated. In fact, the utility of the vehicle is to a large extent dependent upon the improved highway. There can be no question as to the service which is rendered by the highway to the operator of motor truck lines and motor bus lines. The granting of franchises should be followed by a real financial return. There can be no question that the improved highway serves the real property in the rural districts. There is, although more questions may be raised, a real service rendered by the rural highway to the property within the urban limits. Or, if more acceptable, to the people as a whole within the cities. For example, the recent report issued by the Port of New York Authority states that in the port district comprising within its area a population of nearly 8,000,000 people, over 4,000,000 tons of foodstuffs alone are required annually by the people of the district. This means an average of one-half ton per person per year. All of the foodstuffs originate upon a highway, some place, and the nearer to the district that the perishable foodstuffs, such as garden truck, milk, eggs, butter, can be produced, and the more directly and quickly they can be transported from their point of origin, to these people, the cheaper will be the cost and the better will be the quality. Can there be any doubt as to the interest of the urban dweller in the rural highways quite distinct from any direct use which he may make of them? Likewise, can there be any doubt of the real service which the highway renders rural property?

Under these four classes may be grouped the major services which are rendered by the highway, but these do not bear a constant relation to each other, nor does the highway maintain a constant relation to each of these. The truck gardener is more dependent upon improved highways than is the farmer who raises only annual crops.

Thus the relative share of the cost of highways may not remain constant, but it is difficult to harmonize with the tenets of fairness and equity any plan of financing which does not distribute some part of the cost to each of these four services.

A proper financial policy cannot be established unless there is functioning an efficient stable highway administration. For a single state the highway business is an enormous business undertaking. There can be no efficient administrative, engineering or financial policy, unless this business be kept free from partisan politics and the employment of personnel be determined by competency and service. This applies regardless of the unit that is under consideration. With the exception of a very few states, it is apparent that the major highway development for the next decade and probably longer, will be upon the so-called seven per cent system which is now being established under the requirements of the Federal Highway Act of November, 1921. Prior to this act, however, many of the states had established state systems which will be largely, in many cases completely, absorbed in the seven per cent system. Thus, we have now on a national scale the inauguration of the first cardinal principle of efficient highway administration,—the classification of the roads into selected systems. On the seven per cent system federal and state funds will be concentrated until completion. This classification, recognizing with full credit the progress made by many of the states before the federal enactment, is fundamental. Through its operation the roads of greatest importance are first improved and all work done is accumulative toward the completion of a system of inter-connected and correlated traffic lines as between the communities within the states and between the states themselves. As the highway systems are completed, the traffic will become more and more organized and concentrated on the improved roadways. If these systems are not properly selected, they will eventually have to be revised and so much of the investment jeopardized.

In sequence of importance is the proper improvement of the highways so selected. Up to a certain point the steps in the improvement of all types of roadways are the same. The selection of the best location, the building of the road bed by excavation, filling and draining, the building of the necessary culverts and bridges, the building of guard rails, approaches and all the inciden-

tal construction will be as carefully and thoroughly done under an efficient highway administration for all types of highways.

The selection of the type of roadway surface is the all-important item from the standpoint of the highway service and highway finance policies.

Here are the average costs covering 11,017 miles of Federal Aid highways:

Class 1, including the graded and drained, the sand-clay and gravel types, average cost $11,320;

Class 2, covering the macadams, waterbound and bituminous, $20,540;

Class 3, covering the bituminous concrete, Portland cement concrete and brick, $36,100 per mile. Because, however, the average total cost of the Class 1 roadways is only one-third the average cost of Class 3 roadways, it does not follow that the Class 1 should be built to the exclusion of the other. The Class 3 roadways are capable of rendering many times the service the Class 1 types can support.

The service to be rendered must determine the selection of the type of highway. Here again research and investigational studies are rapidly fixing within reasonably definite limits the kind and volume of traffic which can be carried by the different roadway surfaces within reasonable maintenance costs. Such a selection will determine the proper financial policy, for it will provide the basis for the establishment of an annual highway expenditure budget.

The major items of the budget will include the following:

a. Maintenance
b. Reconstruction
c. New construction

Reconstruction is included separately from maintenance for in the progress of highway improvement the replacement of old surfaces is usually by a higher type surface and consequently the road is improved beyond its first condition.

The budget for the state highway department would, of course, apply only to the state system which in general includes the seven per cent system. The estimates would determine the amount of revenue needed for the year's program for the different classes of work. The amounts needed for maintenance and reconstruction will be determined from the records and reports of the condition of roads in the system, for the administration of the state highway systems has developed to the point where it is possible to estimate within reasonable limits the necessary annual maintenance and reconstruction requirements.

The new construction requirements in the majority of the states are capable of absorbing all the funds that can be made available, so it is in the fixing of this fund that the most care should be exercised, but it should be sufficient to complete the first construction of the state system within the shortest period consistent with good management and the maintenance of competitive prices.

The total amount as well as the division of the total between the three funds will vary in the different states, but it is believed that it will be possible to follow the same general principles to the raising of the total revenue required. It is freely admitted that these suggestions are tentative and subject to revision in keeping with the detailed studies which are now being made. Also the relation of urban expenditures and local expenditures for streets as well as rural roads not on the state systems must be given very careful thought. However, it appears more than probable that the state systems will be ultimately extended to provide a sufficient mileage of roads to take care of all the main highway transportation needs of the state.

With these qualifications, then, it is believed that a proper financial policy will require first that all of the maintenance funds be met from the revenues derived from the road user; second, that the costs of reconstruction be met from the revenues derived from both the road user and from state taxes, the relative percentages being different for different states and for the different types of roadways built; third, after deducting the federal aid the cost of new construction should be divided between the road users and other state taxes from both urban and road sources.

Just how the respective revenues for reconstruction and new construction shall be divided between revenues from the road users and other classes of revenues, and how these costs, once apportioned, shall be divided to the several classes of road users and the different classes contributing to the other revenues, must be determined upon the most thorough research and investigation. It has been stated that the total expenditures for rural highway purposes in the United States for the past year were approximately $600,000,000. These revenues came from the following sources:

Federal Aid 14%
State road bonds 7%
State taxes and appropriations 12%
County, township and district taxes and assessments, 14%
Motor vehicle revenues 19%

Federal aid and motor vehicle revenues constituted 33 per cent; the remaining 67 per cent either comes directly or will eventually be paid from state and local taxes. It is believed that a very considerable readjustment of these sources of revenues must be made, so that a larger percentage will be paid by the road user and a lesser percentage from state or local taxes. This statement of motor vehicle revenues is not fairly representative of the total funds collected directly or indirectly from the motor vehicles, for our estimates show the following revenues paid during the fiscal year 1921:

Federal taxes paid by manufacturers on passenger cars and motor trucks	$115,546,249
State registration fees	122,478,654

Personal property taxes	52,500,000
Wheel and privilege license	3,636,543
Gasoline tax, 17 states, calendar year 1922, estimated	11,000,000

A total of $305,161,146, or approximately $30 for each car and truck registered during 1921. This total sum, it will be noted, amounts to over one-half of the total estimated road expenditure for 1921.

Consider also in this connection the question of gasoline consumption. It is probable that the total gas consumption for use in operating automotive vehicles is not far short of four billion gallons per year. An advance of one cent in the price of gasoline on the annual consumption would amount to approximately $40,000,000.

Facts as to the type of construction which is going into the road building program must also be given consideration. For over 11,000 mi. of federal aid roads involving a total cost of over $188,000,000, the surfacing cost is 60 per cent and the remaining 40 per cent is made up of grading 22 per cent, structures 14 per cent, shoulders 1 per cent, engineering 3 per cent. That is, 40 per cent of the expenditures were for the permanent features of the road and the greater part of the expenditures for surfacing can be rightfully considered in the same class, for it is being successfully demonstrated that by supplementary construction such as the placing of new surfaces, the widening by addition of shoulders, the greater part of the investment can be continually maintained and thus preserved indefinitely. Expenditures of this class fall into the category of maintenance and reconstruction, and if continuance of these two can be relied upon the original investment is preserved indefinitely. Therefore, little fault can be found with the soundness of the financing if bonds are issued for new construction if the original investment is thus continually preserved.

A few of the states have made large initial expenditures for construction on their principal highways. These states on their state systems will in the future require large sums for maintenance and reconstruction. The wholly new construction on the state systems will be completed within a few years. Other states have a large mileage of entirely new construction. In addition, the funds for maintenance of the system as a whole will be large, since the policy of taking over the entire state system for maintenance, regardless of its condition as to improvement, is being followed to a considerable extent. The results accomplished indicate that it will be necessary for the states generally to adopt this policy. It is evident, therefore, that the time is rapidly approaching when the principal demand for road funds in one group of states will be for maintenance and reconstruction, and in another group and by far the larger, for maintenance and new construction.

Of all these requirements it appears that the funds for the new construction in the amounts that will be needed, will be the most difficult to secure. The public should not be called upon to bear this entire cost as an annual expense. Rather is it fair to distribute these costs over a period of years extending beyond the time of the maximum expenditures for new construction. It is not doubtful that succeeding generations will enjoy the use of the highways which are being built now, and there is nothing unfair or to be criticized in pursuing a financial policy which distributes a portion of the cost beyond the immediate period. No enterprise requiring funds in the large amounts that they will be required for the new construction of highways can go forward without anticipation of revenues.

Experience in the administration of highway work has already established certain definite principles without the observance of which it would be highly unsafe to resort to bond issues. The major principles may be outlined as follows:

1. As a general proposition state, not local, bonds should be issued for the building of the state highway system. In any case the total amount of bonds to be issued for any one year or over a period of years in any state should be subject to the control of one central body.

2. Sufficient revenues must be derived from the users of the highways to pay all of the maintenance and a percentage of any reconstruction charges.

3. All bond built highways ought to be maintained under the direct supervision of the state Highway Department, which also must have jurisdiction of the revenues from the road users, and the proper maintenance of all bond built roads must be considered a first lien upon such revenues.

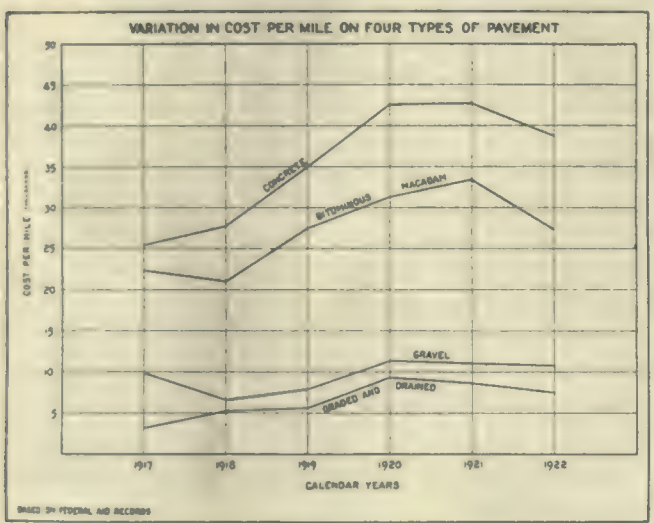
4. The proceeds of bonds must be devoted to a system of roads so devised that as the system is completed these roads will in fact continually serve the major traffic in the vicinity. This means that the only safe sequence of improvement is in the order that the different sections of the system serve the traffic.

5. Bonds should not be issued in an amount beyond the ability of the traffic of the present and immediate future to pay revenues sufficient for the proper maintenance of the roads built from the proceeds.

6. The type of roads built with bonds should be adjusted to the traffic which they will be called upon to bear within the reasonable future.

It will be noted that little has been said as to the uses which are to be made of the highways, but it must be remembered that the whole question of highway transportation is in its infant stages. Very careful investigations and studies are now going forward to determine both the economic limitations of highway transport and of the necessarily adjusted highway construction. We have made rapid progress during the past two years toward such determination, and the suggestions which have been made are based upon an administration of a highway program predicated upon the results and determinations of these scientific researches and investigations. The science of highway administration is being

rapidly developed, but the principles and information available must be given the widest publicity. It makes no difference how sound a policy may be adopted by one administration. The work of providing a road bed for the rolling stock now in existence will extend over more than a decade into the future, and it will lie with the public to determine whether the policies shall be carried out or whether there shall be a change with every change in the complexion of the administration. This is the most uncertain feature of any connected with the financing of road improvements, particularly where it is desirable to issue bonds for a long period. If permanent policies can be adopted and carried forward without change over a period of years, the necessary roads can be built without undue burdens upon the pub-



lic. But only can this be done by foreseeing now and adhering to safe and sound financial policies. The objective, after all, is to furnish the cheapest possible highway transportation, which involves both the rolling stock and the road bed. But the public have undertaken to provide the road bed as a public responsibility, and there should be no misunderstanding of the huge sums which are involved in the undertaking.

SCHOOL CHILDREN WILL STUDY HIGHWAY TRANSPORT

Prompted by the success of the educational outline on highway transport prepared for university use under their direction by Prof. Lewis McIntyre, the officials of the Highway and Highway Transport Education Committee have now turned to Prof. Buckner of the School of Education of the University of Pittsburgh to translate the book into language designed for use by high school students throughout the country. The new pamphlet will be prepared in co-operation with officials of the U. S. Bureau of Public Roads, the U. S. Bureau of Education and other organizations represented on the committee and will be the first comprehensive effort to place the subject of highway transport before the high school students of the country.

Mrs. Florence Fox, specialist of educational systems in the Bureau of Education, has been working for several months in the preparation of an outline on highway transport for use by students in the fifth and sixth grades. This work has taken the form of project teaching, by means of which the pupil examines the relation of highway location, construction and use to the historical, civic, geographical and economic development of the community in which he lives, as well as learning something of their national significance. The course is now being demonstrated in the Thompson grammar school in Washington, D. C. So interested have the pupils been that they have spent much time out of school hours in having their parents drive them to the various bridges and highways of Washington in order to learn something about them at first hand.

REACH AGREEMENT ON HIGHWAY BILL

The deadlock in Congress on highway legislation came to an end June 3 when conferees for the Senate and for the House of Representatives compromised their differences. The Senate conferees agreed to accept the Dunn bill instead of a direct appropriation under the provisions of the original federal aid act. The House conferees in turn agreed to changes in the Dunn bill, the most important of which is an increase in the limit of federal participation per mile of road. The bill, as agreed upon in conference, authorizes the expenditure of $50,000,000 for the next fiscal year, $65,000,000 for the fiscal year which ends June 30, 1924, and $75,000,000 for the fiscal year ending June 30, 1925. Federal aid is limited to $16,250 per mile during the fiscal year to end June 30, 1923, and $15,000 per mile thereafter. The yearly expenditure of $6,500,000 for forest roads and trails is now authorized for both 1924 and 1925 instead of for 1924 only as provided in the original House bill.

BIG PROGRESS THIS SEASON EXPECTED IN ROAD BUILDING

From the progress being made in Federal-aid work, the states are exerting every effort to make the present season a big one for road construction, according to the U. S. Bureau of Public Roads. In February, $3,906,000 was allotted, and in March, the figure jumped to $12,029,000.

In April, plans for 225 projects were approved by the bureau, the second largest number in the history of federal aid, and indications are that the number for May will be even larger. In the past the peak in volume of plans approved came in June and July; the earlier occurrence this year shows that the states are making good their promise to get as much work under construction as possible to take advantage of lower prices and relieve the unemployment situation. A considerable portion of the projects for which the plans are approved should get under construction during the summer and add greatly to the 13,950 mi. under construction on March 31.

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

Founded January, 1892

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Editor

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Copy for classified and other advertisements where proofs are not required will be accepted until noon on Monday of the week of issue.

Articles by road builders are solicited. They should be short and, if possible, accompanied by photographs. Those accepted will be paid for at current rates.

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THE COMPROMISE ON HIGHWAY LEGISLATION

The demand on the part of the House of Representatives for consideration of the highway bill introduced by Chairman Dunn of the House Committee on Roads has resulted in the acceptance of that bill by the conferees for the Senate after various changes had been made. The bill, as agreed upon in conference, is more acceptable to road builders than the original Dunn bill, but probably not as acceptable as the appropriation voted by the Senate under the provisions of the original federal aid act.

In the matter of federal aid participation, the bill now sets the limit at $16,500 per mile for the next fiscal year and at $15,000 per mile thereafter. The present law sets the limit at $20,000 per mile and the original House bill set it at $12,500 so that it is very evident that the conferees did not base their decision on a study of the merits of the two laws, but on the simple arithmetical problem of striking an average. With increased traffic over the highways of the country necessitating better, more durable and therefore more expensive types of pavement, it did not seem wise to cut the limit of federal participation at all on account of the hardship worked on the western states which are thinly populated and dependent on federal aid.

The other major change in the Dunn bill lengthened the program from two years to three. The House committee provided for two years only in the hope that the financial situation would improve in that period and that it might be possible to return to an appropriation of $100,000,000 in 1925. The conference set $75,000,000 for the fiscal year ending June 30, 1925, $65,000,000 for the fiscal year ending June 30, 1924, and $50,000,000 for the coming year. That amounts to a reduction of $15,000,000 next year and $10,000,000 in 1924, and removes all hope of getting the larger appropriation in 1925. This reduction was made in spite of the fact that it will delay the normal development of our highway system and was the subject of general protest from highway officials.

VOLUME AND WEIGHT

Frequently, the road contractor finds it necessary or advisable to import broken stone instead of operating a crushing plant on the job. When he figures on such a proposition, he is moved by two considerations, the price of the stone and the cost of transportation. The former, in most cases, is quoted as so much per ton at the quarry. Transportation would be by rail, by water, or by motor truck. If by rail or water, the motor truck would probably be used to haul to the job from car to barge. Rail and water freight charges are made on a weight basis and the tendency is for haulage by motor truck to be paid for on the same basis. When hauling by motor truck from a car or barge, it is simpler to pay by weight because the correct weight will appear on the bill of lading and there is no need of measuring or checking up on the loads. Even when drawing direct from the quarry, it is easier to weigh a load than it is to measure it and there is much less chance of error.

In the majority of cases then, the contractor will find both the price of the stone and the cost of transportation charged on the basis of weight. After he has placed it in the road bed, he is paid for it by volume, either by cubic or square yard. Now, it may well be assumed that he will find two or more quarries in his locality producing broken stone of different kinds, and that each kind will meet the requirements of the specifications under which he is working. These different kinds of stone will vary in price and they will also vary in weight. It is evident that a stone weighing 2,800 lb. to the cu. yd. will not build as much road per ton as a stone weighing 2,500 lb. to the cu. yd. This loss of volume is not lost sight of by the producer and governs the price so that the heavier stone is the cheaper. It is a simple matter for the contractor to figure whether the difference in price is sufficient to compensate him for the loss in volume. And after that, there is the matter of transportation charges,—paid for by weight. It is again evident that it is going to cost more to ship the heavier stone. Is the difference in price sufficient to cover that loss too?

This matter is one for each contractor to determine for himself in his own individual case. It is brought up here in the belief that it is a point which many contractors might overlook and one to which they might well give consideration.

Recent Developments in Highway Research

Experimental Work on Bates, Arlington and Pittsburgh Test Roads Continues—Bureau of Public Roads Devises New Instruments for Tests

The second of the traffic run tests to be conducted on the Bates experimental road was completed on Saturday, May 13, when the 63 sections of the test highway had been subjected to 3,200 applications of the last increment of load. The load which was applied to the pavements during this run was 3,500 lb. on each rear wheel of the trucks and 2,150 lb. on each of the front wheels. Three-ton Liberty trucks, with bodies attached, were used to produce the load, and brick piled in the body made up any deficit in weight. The loads, as applied, corresponded to 350 lb. per in. of nominal width of rear tire, and 430 lb. per in. of width of front tire. Though it was originally intended to apply this load only 1,000 times to each edge of the sections, it was later decided to subject the pavements to a greater number of applications in order that the thinner sections might be given a thorough test to determine their resistance qualities.

The load was first applied as in the preceding test, the trucks traveling on the extreme edges of the pavements. After 627 applications had been applied in this manner, it was decided to move the traffic in on the north side with the outside rear wheels of the trucks traveling 2.5 in. from the edge. The object for making this change of traffic position was to study the results on pavements with the loads applied at a certain distance from the edge. It seems entirely possible that the material necessary to construct a narrow rigid slab of sufficient strength to carry given wheel loads, if used to construct a thinner slab of greater width, would result in a pavement of equal or greater durability. Such a result would be due to the fact that wide roadways would in all probability lessen the frequency of the application of maximum loads to the weak points, the corners. Reasoning along this line, it is quite possible that added load carrying capacity can be secured more cheaply by adding to the width of the pavement than in any other way.

After a total number of 1,167 applications of this load, it was noticed that exceptionally strong support was given the corners of the sections by the adjoining slabs. In other words, the pavement, due to prevailing warm weather, had expanded to such an extent that the loads were distributed across the joints which contained no dowels in the same manner as over joints containing dowels. This condition eliminated to a great extent the free corners, the weakest points in the slabs, and resulted in a greater strength of section than is normally the case during the late fall, winter, and spring months. To prevent this condition, one transverse cut about 1 in. wide was made through each section of pavement of rigid type and the cut thus formed was filled with asphalt. The traffic was then started and 1,000 additional applications of the load made.

Upon the completion of 2,167 applications of this load, night traffic was started. Preliminary investigations on the Bates road showed conclusively that during the night the edges of rigid type pavements curl up and, while in this position, receive very little or no support from the subgrade. Pavements in the localities where night traffics is imposed upon them, especially in the vicinities of large cities, must necessarily withstand this extreme condition of strain and it was with this in mind and to gain an insight to the actions of various types of pavements subjected to this condition, that the night traffic on the Bates road was introduced. An electric lighting unit was installed at the test road in order to facilitate the night runs.

As the maximum curling of pavement has been indicated to take place between the hours of 9:00 P. M. and 6:00 A. M., the night traffic was applied during these hours. Fourteen trucks were employed in both the night and day runs with the 3,500 lb. load, approximately 350 applications being secured in the daytime and 300 at night. Due to an extremely heavy rain storm at midnight on the second night of the run, traffic was temporarily suspended and only 167 applications were secured at that time.

Thus, up to date, the pavement has been subjected to:
1,000 round trips of the trucks loaded with 2,500 lb. on each rear wheel and 2,150 lb. on the front wheels, daytime loads, the outside rear wheel running directly on the edge of the pavement;
627 trips with loads of 3,500 lb. on each rear wheel and 2,150 lb. on each front wheel, daytime loads, outside rear wheel running directly on the edge of the pavement;
540 daytime trips with the same load but with the outside rear wheel running directly on the edge on one side of the pavement and 2.5 ft. in from the edge on the other side;
1,000 daytime trips with the same load and with the trucks applying the load along the same line but with the joints of the pavement cut open;
1,033 night trips with the loads applied under the same conditions as previously.

Observations of the effects of the traffic were made in the same manner as in the first run on the road, observers being assigned to a certain number of sections to record all cracks and failures as they occur. Traffic breaks were considered failures under this load as under the first load.

A 3,500 lb. load applied 6 in. from the corners on the thinnest (4-in.) rigid pavements produces tensil fibre stress of about 500 lb. per sq. in., considering the

corners as unsupported cantilevers. As the test specimens, which were cast of the same material and at the same time as the sections were laid, show a modulus of rupture of from 600 lb. to 650 lb. per sq. in., the actual stress produced in these sections is approximately 75 to 80 per cent of the ultimate, and therefore corner breaks in all such sections might be expected. This same load applied in like manner to 5-in. rigid pavements produces tensile fibre stresses of about 300 lb. per sq. in.

After the line of traffic was changed from the edge to 30 in. in on one side of the pavement, there was no further failures on that side but, on the opposite side, there were 14 corner breaks in all, 6 occurring before the joints were cut and 8 after the joints were cut. There is no doubt but that the change of traffic has prevented further failures on that side of the pavement.

The opening of the cracks and joints due to cold weather makes a marked difference in the carrying capacity of a given pavement as is shown from the results obtained from this test. Only 2 corner breaks occurred during the 1,167 applications of the 3,500 lb. load before the joints were cut and 7 corner breaks occurred during the following 1,000 applications of the same load applied after the joints were opened.

Apparently, the night loading was but little, if any, more serious than the day loading, possibly due to the fact that the subgrade was crowded away from underneath the edge of the pavement, before the night runs were made, by the continuous applications of the truck loads along the edges. If this is the condition, the stress to which the slab was subjected during day loading would be as great as during night loading and that would account for the fact that, as a result of the 1,033 applications of the night loads with joints open, only two additional breaks were observed while, as a result of 1,000 applications of day loads applied just previous and under the same conditions, six breaks occurred.

The next increment of load to be applied will be such that each of the rear wheels will carry 4,500 lb. and each of the front wheels 2,000 lb. The load on the front wheels is lessened under this load, due to the increased weight in the rear taking some weight off of the front of the truck. One thousand or more applications of this load will be made in the day runs and there is some possibility of running the same number at night. The latter step is to be considered after the completion of the day run.

Experimental road work at Arlington to Continue

A comprehensive program of road-building research and investigation during the coming season at the Arlington Experimental Station near Washington, D. C., is announced by the U. S. Bureau of Public Roads. Impact tests on pavements, subgrade studies and other experiments, which last year aroused much interest among engineers, will be continued as well as other lines of work under way last year and several new ones.

Bituminous wearing surfaces are to be investigated to determine the reason for the formation of waves and irregularities and to settle mooted questions concerning the proper mixture and the proper mineral aggregates to be used in bituminous roads. More than 30 sections of different types of bituminous construction will be built. These will include mixtures of different mechanical grading and with different percentages of bitumen of several degrees of hardness. Sections are being constructed on a circular track about 600 ft. in circumference, the roadway being 13 ft. wide. On this roadway will be operated a 5-ton army truck equipped with solid tires. The truck will be operated in a varying path so as to cover practically the entire width of the roadway and will travel at a speed of from 12 to 15 mi. an hour for five or six months, or until some results are obtained leading to the solution of the problems involved.

Another test will be made on about 65 sections of concrete wearing surface which will be constructed on a circular runway about 4 ft. wide and 650 ft. in circumference. Each section will differ in the quality of the concrete used which will be varied by use of different aggregates, different proportions of the mix, and different quantities of mixing water. On this runway, will be operated a specially constructed car with two truck wheels equipped with solid rubber tires and loaded to represent a truck. The car will be guided by small railroad rails to hold it in position and the power will be applied by means of an electric motor to the rear wheel. This apparatus will be operated around the circular runway at a speed of probably 20 mi. an hour. The test will involve the use of truck wheels equipped with different kinds of tires and will include the use of non-skid chains. A steel-tired wheel will probably also be used to get the effect of an accelerated wear test.

The object of this experiment is to determine the relative wear of the different concrete sections when subjected to traffic equipped with different types of wheel and also to furnish a comparison between actual service conditions and laboratory tests.

In a rather elaborate series of experiments, the bureau has studied impact of trucks on roads, and has determined approximately the magnitude of impact force under different truck and road conditions. The effect of such impact on concrete pavements and several types of road on concrete base was studied and reported on last year. This series of experiments is to be continued and enlarged. Over 120 road sections or slabs have been constructed in duplicate series. One series is on a carefully drained dry subgrade; the other series is on the same kind of subgrade except that it is kept wet and as nearly saturated as possible by means of an underlying drain tile and side ditches filled with water. The testing of these slabs will be carried on by means of a new impact machine, now being constructed, which simulates the action of the rear wheel of a truck. On this machine may be mounted truck wheels of different sizes.

and weights carrying different kinds of truck tires. This apparatus may be so operated as to reproduce the different loading and equipment conditions of a large variety of trucks. The slabs will be hammered by means of this machine in the center, on the corners, and on the sides so as to obtain the relative strength under these different conditions.

Subsoil investigations are being continued for the purpose of studying and investigating relative stability, moisture condition, and supporting value. Different methods of determining the bearing value of soils are also being studied, that is, as to whether small or large areas should be used in determining the relative bearing value.

The warping effect of temperature and moisture conditions on concrete pavements is also being investigated. Temperatures and movement are being recorded graphically on continuous charts. In addition to these temperature and movement measurements, the pressures on the subgrade under the concrete slab are obtained by means of soil pressure cells. This investigation will give some definite information concerning the support offered by subgrades to rigid concrete roads.

The transmission of loads through different types of pavements to the subgrade is being investigated by means of soil pressure cells placed on the subgrade under the pavements. This test will also serve to show the relative support offered to brick and other types of block pavement by concrete bases and broken stone bases.

A large number of prominent engineers and others interested in road work have visited the Arlington Experimental Station to witness the preparation and conduct of these experiments. It is intended to have all these projects in full operation by the middle of June. Visitors are always welcome and those in charge of the work are always glad to give any information desired about the experiments.

Tests Resumed on Pittsburgh Highway

The California Highway Commission with the cooperation of the U. S. Bureau of Public Roads has resumed traffic upon the test highway at Pittsburgh, Cal. The tests which were interrupted last fall will be continued to completion and then an entirely new series will be started. The purpose of the tests is to investigate the strength of various types of concrete roads and the effect upon them of steel reinforcement. There are at present 46 trucks available for the tests. They carry 5-ton loads and run in opposite directions continuously 8 hours per day for 6 days a week at a constant speed of 14 mi. per hour.

New Apparatus to Record Road Surface Irregularities

It has been suspected for some time that roughness in a road surface is objectionable, not only from the point of view of those who travel over the road, but that it is also productive of damaging forces which affect the integrity and life of the road. It is for this reason, no less than for accommodation of travelers that clauses have been inserted in modern specifications limiting the degree of roughness which will be permitted in the finished pavement. Such clauses, in fact, are inserted primarily with the protection of the road in mind, because the minor roughness which it is their purpose to limit is not particularly objectionable to traffic.

Although there has been a well founded belief that such roughness does add to the intensity of the destructive force of impact, there has heretobefore been no means of measuring the effect of it; nor has there been any instrument by which all the minor variations of surface level which make up roughness could be measured with accuracy.

Two instruments have recently been devised by the Division of Tests of the Bureau of Public Roads for the purpose of supplying this information in connection with the accelerated traffic test which are being conducted under the direction of Mr. Clifford Older, Chief Engineer of the Illinois Division of Highways on the Bates experimental road. The two instruments are known respectively as a profilometer and an accelerometer.

The profilometer which is to be used for measuring roughness has just been constructed at the laboratory of the Illinois Division of Highways. By means of this device the profile of any part of the road surface can be quickly and accurately obtained. Aside from its use in highway investigations, it will be of particular value to all engineers engaged in highway construction since it affords a quick and simple means of determining if road surfaces conform to the degree of smoothness required by pavement specifications.

The apparatus consists of a straight edge or track 24 ft. long and a recording device which, when drawn over the track, records accurately and autographically the profile of the pavement beneath. The track as used on the Bates road is supported by three bicycle wheels and consists of two wooden trusses 24 ft. long by 20 in. high with a 3 in. space between them. Four turnscrews, two at each end, permit of leveling the track at each set-up, while a piano wire under constant tension which is stretched from end to end gives a datum for detecting any sag in the track.

The recording apparatus consists of an American strainograph to the pen arm of which is attached a rod connected with a brass wheel which rests on the pavement surface. The vertical movements of the small wheel caused by irregularities in the surface are traced on the recording paper by the pen. The instrument is mounted on a 1.5x8x30 in. wooden platform which rides over the trusses on four wheels, each 2.5 in. in diameter and 2 in. wide. The platform is kept centered by two wheels which run in the 3-in. space between the trusses.

For drawing the recording device over the track, a wire cable is used attached to each end of the platform

and passing over a pulley at each end of the trusses. The pulley at one end is operated by a crank.

In addition to the autographic record of the profile, the summation of the vertical ordinate of the surface profile can also be obtained from the profilometer by means of a special attachment which consists of a fibre strip 0.5 in. wide by 6 in. long which receives the pen arm movement and operates against the recording wheel of a planimeter in such a way that the upward movement only is recorded. For convenience in securing the total of upward movements, a record is made at every ten revolutions of the planimeter wheel by breaking an electric circuit. The summation of vertical ordinates shown by the attachment, divided by the length of surface passed over, gives an average ordinate which can be considered as a roughness factor of the particular surface.

The rolls carrying the recording paper are driven by a pulley which, by contact with a cord fastened at each end of the track, is caused to revolve as the platform is drawn along the track. Thus the paper on which the record is made moves a distance proportional to that traversed by the wheel on the pavement surface. The ratio of paper length to observed surface distance in this case is about 1.10 .

This apparatus can be used to check up the smoothness of any length of pavement. As a first step levels are taken on points 18 ft. apart. The track is then set over these points and the recording apparatus is drawn over it. When these points are plotted on the profile paper, the records can be placed directly on the points and so give a continuous and accurate profile of the surface for any required distance. One of the apparent advantages of the apparatus is the fact that the roughness can be determined accurately and in a comparatively short length of time. On the Bates experiment, this apparatus will be used to determine the roughness of the surface before it is subjected to traffic as well as the effect of the traffic upon the surface.

The profilometer will be used also, in conjunction with the accelerometer attached to one of the test trucks, for determining how roughness of the surface influences the impact of the motor wheel. The accelerometer which was improvised by the Bureau of Public Roads consists of the recording part and case of an American strainograph, to the pen arm of which is attached a rod supporting a weight suspended between two compression springs. This device is attached by means of rods directly to the rear axle of the truck. In this apparatus also the recording paper moves a distance proportional to that passed over by the motor wheel, the roll carrying the paper being driven by a speedometer cable and a small rubber tired wheel, which rests against the brake drum of a rear wheel of the truck.

The theory of this device is simple. If there is no vertical acceleration of the axle, the weight will not change its position with respect to the axle and the record will be a straight line. Any vertical acceleration, however, will cause the weight, and consequently the pen, to vary from a straight line and the greater the acceleration the greater will be the variation from a straight line. This variation is a measure of the force which causes it and the force corresponding to any particular variation can be determined by calibrating the springs. Knowing this force and the mass of the wheel and axle, it will be possible to compute the corresponding impact.

Having secured from this instrument the graphs showing relative impacts produced by different parts of the surface and from the profilometer graphs showing the roughness of these parts of the surface, a means results by which the effect of the surface roughness on the impact of motor wheels can be studied with a fair degree of accuracy. A study of the chart secured from these two instruments shows both the variation in the road surface and the effect of this variation on the moving motor truck wheel.

By means of the accelerometer it is intended to study the effects of surface variation on the rear wheel of a truck traveling at rates of 5, 10 and 15 mi. per hour with no load and with 2½ and 5-ton loads. It will also be very interesting to determine the increase in wheel impact accompanying the increase of corrugations in the non-rigid types of pavement.

Bearing Power of Soil Determinator

To measure and compare the bearing values of the various types of subgrade soils the Bureau of Public Roads has designed and built an apparatus which has promise of good results. It is simple in design, light, easily built, and is capable of measuring the bearing value of almost any soil containing an appreciable amount of moisture. It may be operated by one man with two helpers and offers a suitable means of securing valuable information as to the load-carrying capacity of subgrade soils before pavements are laid.

The apparatus has only four separate parts, tripod, shot container with bearing foot, shot funnel, and Ames dial. The load is applied by pouring measured quantities of fine shot into the funnel at regular intervals, while the penetration of the foot into the subgrade is indicated by the Ames dial mounted above the tripod head. To operate the apparatus, the tripod is set firmly in the ground and the shot container with foot is brought to a truly perpendicular position as determined by the small level just above the shot container. By a slight movement of the bearing foot the direction of the load to be applied is made perpendicular to the subgrade. The shot funnel is next placed in proper position at the top of the tube and the Ames dial clamped to the tube with the dial foot resting on the top of the tripod head and, when the dial is adjusted to read zero, all is ready for the test.

The Decrease in Wages for Common Labor has made it unprofitable for the State of Nebraska to use convicts on highway construction.

MEETINGS

Calendar of Coming Meetings

June 12-15—Canadian Good Roads Association—Ninth annual convention, Victoria, B. C. Secretary-treasurer, George A. McNamee, Birks Bldg., Montreal, Canada.

June 19-20—American Construction Council—Organizing meeting, Washington, D. C., R. C. Marshall, Jr. 1053 Munsey Building, Washington, D. C.

June 26-July 1—American Society for Testing Materials—Twenty-fifth annual meeting, Atlantic City, N. J. Secretary, C. L. Warwick, Engineers' Club Bldg., Philadelphia, Pa.

Aug. 9-10—Custer Battlefield Highway Association—Annual meeting, Sheridan, Wyo. Secretary, W. D. Fisher, Sheridan, Wyo.

CONFER ON TRAFFIC SIGNAL COLORS

Recommendations to the American Engineering Standards Committee in regard to the standardization of colors for traffic signals were made at a conference held at the Engineering Societies Building in New York City, May 23. The conference was called at the request of the Illuminating Engineering Society and the International Traffic Officer's Association and invitations were sent to all interested organizations. It was attended by the representatives of 34 organizations, including automobile, highway, railway, traffic, and engineering associations; 8 representatives of city and state governments; and the representatives of 14 manufacturers of traffic signals. Written communications were received from several delegates who were unable to be present. The Canadian Engineering Standards Association represented Canadian interests.

The meeting was called to order by Mr. A. W. Whitney, Chairman of the Engineering Standards Committee who outlined the relation of the committee to the conference. Dr. C. H. Sharp, on behalf of the Illuminating Engineering Society, presented a statement outlining the considerations which lead the society to request the calling of the conference. Dr. John H. Harriss, the inventor of the traffic signal system on Fifth Ave., New York City, spoke and offered the full cooperation of the New York City Police Department to the end of national uniformity in colors for traffic signals. Mr. A. H. Rudd of the American Railway Association presented a paper which summarizes the situation as affecting steam railroads and suggested lines along which that association would like to see standardization. A paper by Mr. H. B. Flowers on behalf of the American Electric Railway Association was read by Mr. Guy C. Hecker. Speaking for the Conference of Motor Vehicle Administrators, Mr. A. L. McMurty said that the administrators, felt that they should not make any technical recommendations to the conference but that they were greatly interested and would cooperate to the fullest extent. The hope that, as a result of the conference, the Canadian Engineering Standards Committee might initiate similar deliberations and work along lines parallel to the American committee, was expressed by Mr. R. J. Durley, secretary of that body.

After lengthy and detailed discussion, a resolution was passed that there should be national uniformity in the use of colors for signals and the scope of the work was defined as follows:

The use of colored lights an all highway vehicles.

Their use on all signals along highways and at curbs, both permanent and temporary.

Their use for highway crossing signals for steam and electric railways.

A coordinated relation to systems of flashing, moving, or similar lights.

A coordinated relation to systmes of flashing, moving,or similar lights.

Colors for non-luminous as distinguished from luminous signals.

Recommendations on the use of colors for emergency exit signals.

Methods of specifying or defining colors for signal purposes.

Any other closely related matter which, in the opinion of the sectional committee, form a part of the subject to be considered.

It was unanimously resolved that the detailed technical work should be carried out by a thoroughly representative sectional committee under the auspices and procedure of the American Engineering Standards Committee, and, further, that the recommendations of the conference be transmitted to the committee without definite recommendations on sponsorship.

TO HOLD HEARING ON HIGHWAY MATERIALS SPECIFICATIONS

The special committee appointed by the Board of Estimate and Apportionment of New York City to formulate standard specifications for highway materials will hold a public hearing in the City Hall, Borough of Manhattan, June 16, 1922, at 10:30 A. M. The specifications, methods of tests, and methods of sampling, which the

committee will recommend, will be used in connection with the purchases of highway materials by the city and the object of the hearing is to give all those who may be interested, contractors, trade associations, and others, an opportunity for an expression of opinion on this matter.

ROAD MAKERS CONFER WITH MOTOR MANUFACTURERS

Representatives of the American Association of State Highway Officials, the National Automobile Chamber of Commerce, and the Bureau of Public Roads met in Washington at the federal bureau, May 24, to discuss important matters relating to highways and highway transport. The meeting was the first of a series which, it is expected, will eventually lead to conclusions that will have an important bearing on legislation relative to these subjects. The conference decided to select those subjects which are of immediate importance in the highway transport field; such as broad questions of highway finance, regulation, and operation; to report back to its members and later to gather for further detailed discussions. No definite time was set for the next meeting but sentiment of those present favored a two-day session within the next month or two.

NEW AUTOMOBILE ASSOCIATION FORMED

The National Automobile Association, a nation-wide organization of automobile clubs and associations, was launched in St. Louis, Mo., May 19 and 20, following the withdrawal from the convention of The American Automobile Association of clubs and associations representing twelve states and 243,000 individual members. The states represented in the new movement are Ohio, Indiana, Illinois, Kentucky, New York, Minnesota, Texas, Nebraska, Missouri, Iowa, Dakota and Wisconsin. The withdrawal followed the failure of the chair to exclude from voting in the convention the delegates of the Chicago Motor Club on the protest of several representatives from different states. The protest was based on the fact that the Chicago Motor Club was not affiliated with the Illinois State Automobile Association and that its admission was illegal under the by-laws which provide that, where a state association already affiliated with the A. A. A. holds the franchise for the state, only clubs may be admitted which come in through the state organization.

A national conference will be held at the Congress Hotel in Chicago, June 19, for the purpose of perfecting the organization of the new National Automobile Association.

INVITATION TO FIRST MEETING OF CONSTRUCTION COUNCIL

Lacking facilities at present for direct communication with the thousands of important men in the construction industry, the temporary directing committee of the American Construction Council begs leave through the columns of the engineering, architectural and construction press to extend a personal invitation to each member of the industry to attend the organizing meeting in Washington, D. C., June 19 and 20.

The step contemplated, that of bringing together for cooperation in behalf of the industry and of the public all the elements of construction activity—engineers, architects, labor, the contractors, the manufacturers and dealers, and the financial interests—is epochal in American industry. It deserves, and promises to have, the full support of the entire industry. A full representation at the organizing meeting will be the best testimony to the country of the solidarity of construction interests in the new movement.

Full details of the plan are set forth in a comprehensive pamphlet, procurable from the temporary office, 1053 Munsey Building, Washington, D. C. The meeting will be held in the Washington Hotel. Mr. Hoover will preside.

WOULD REGULATE SIZE, WEIGHT AND SPEED OF MOTOR TRUCKS

At the convention of the National Highway Traffic Association held on May 12 in New York City, the report of the national Committee on "Regulations Covering Speeds, Weights, and Dimensions of Motor Trucks" was given by George H. Pride, Chairman; as follows:

The committee unanimously decided upon the following extreme dimensions for motor trucks: width, 96 in.; height 12 ft. 6 in.; length 30 ft.; the maximum axle loading to be 22,000 lb., and for solid tires 800 lb. per sq. in. of tire width measured at the base of the rubber.

There still exists a diversity of opinion among the members of the committee as to the maximum permissible weight per vehicle, the highway engineering members refusing to approve the 28,000 lb. maximum which was the concensus of opinion of the balance of the committee. At the last annual convention of the association in April, 1921, this question was referred to the members there assembled, and the convention by a large majority approved the 28,000 lb. limit, the highway engineering members still votely adversely.

The following speeds were adopted:

Gross Weight	Country	City
4,000 lbs.	25 mi. per hour	20 mi. per hour
8,000 lbs.	20 mi. per hour	20 mi. per hour
12,000 lbs.	20 mi. per hour	15 mi. per hour
16,000 lbs.	15 mi. per hour	15 mi. per hour
20,000 lbs.	15 mi. per hour	15 mi. per hour
24,000 lbs.	15 mi. per hour	15 mi. per hour
28,000 lbs.	15 mi. per hour	15 mi. per hour

We still consider that there is insufficient data available on the use of pneumatic truck tires to enable us to make any definite recommendations concerning them further than to say that, the use of pneumatics seems to reduce the force of impact on the road surfaces to a certain degree, and also that, experiments seem to indicate that they cause fully as much wear on hard surfaced roads as do the solid tires, and even more wear on gravel and certain forms of macadam.

The only trailers that should be permitted to operate through congested regions, would be so constructed that

they would have no tendency to weave from side to side.

Laws concerning the number of trailers which would be permitted behind one tractor, should be sufficiently elastic to limit the number to one, where traffic congestion is great, and to permit more than one where such congestion does not exist.

WIDE DISCRETION URGED IN REGULATING ROAD TRAFFIC

Regulation of the character and weight of highway traffic to prevent undue injury to the highway is an administrative matter and can not be properly taken care of by detailed and arbitrary legislation. This is the conclusion of the Bureau of U. S. Public Roads, based on experiments to determine the effect of all kinds of traffic on road surfaces and observations on conditions throughout the United States.

Even in a single State conditions vary to such an extent that a load which may be carried on one road without injury may cause untold damage to another. Under the average regulatory law thus far made effective, the greatest service has not been secured from the best roads, nor the safety of the lesser capacity roadways assured. The influence of subgrade soils, tire equipment, distribution of load to the wheels, speed and many other variables is too complex to be written into law.

The seasonal variation alone in the carrying capacity of the roadbeds, due to moisture conditions, is one of the most serious of all the causes of road damage. Highway authorities therefore must be given wide discretion in traffic regulation. The bureau urges that as a solution of the problem the state highway officials of each state be given broad powers, so that traffic can be regulated to suit conditions as they exist at any particular time.

LOCATION OF RURAL MAIL BOXES

Location of rural mail boxes along the improved hard surfaced roads is the subject of a statement by the Fourth Assistant Postmaster General, as follows:

It has been brought to the attention of the department that it is the practice of some postmasters and rural carriers to insist that the boxes of rural patrons shall be erected near the edge of the crown of hard surfaced roads. It is the experience that boxes so located are an obstruction and dangerous to traffic and seriously interfere with the operation of the machines used in the maintenance of roads of this character.

It is deemed essential that there be cooperation between the representatives of this department and the authorities charged with the upkeep of the roads, and it is directed that postmasters shall, when requested by the state highway engineers or other competent authorities, require rural patrons to erect their boxes on the outer edge of the shoulder line of hard surfaced roads, and in such position at the edge of other roads, that they shall not be an obstruction or a menace to traffic, while at the same time being accessible to the carriers without the need of their leaving their conveyances.

Although not a requirement, it is the opinion of the department that it would be of advantage if persons having boxes on improved roads and on those over which there is heavy traffic would paint the post white, because it would add to their visibility at night and tend to reduce accidents.

11,017 MILES OF ROADS BUILT BY FEDERAL AID SINCE 1916

The U. S. Bureau of Public Roads reports that on March 31 there had been completed since 1916, 11,017 mi. of federal-aid road and gives the mileage of each type and the average cost per mile. The figures are based on a large volume of work and are the most recent and reliable figures giving average costs for the whole of the United States. The figures cover the entire cost of construction excluding large bridges and in a few cases the cost of engineering is not included.

Type	Cost Per Mile	Miles Constructed
Graded and drained	$9,200	1,752
Sand-clay	9,850	1,338
Gravel	9,230	4,389
Water-bound macadam	14,000	294
Bituminous macadam	25,720	382
Bituminous concrete	43,500	511
Concrete	36,600	2,104
Brick	46,875	224

These figures are based on the entire period of operation of federal aid, but the major portion of the work has been done since 1918.

The Greater Sheridan Road Association was recently formed in Milwaukee for the promotion of the 650-mi. Sherdian Road from St. Louis, Mo., to Houghton, Mich.

PERSONAL MENTION

John D. Williams, Chief Clerk of the Indiana State Highway Department, has been appointed director of the highway department to succeed Lawrence Lyons, resigned.

H. L. Albert of Green Bay, Wis., has been appointed city engineer of Seymour, Wis.

L. V. Campbell, formerly an office engineer in the headquarters office of the Montana State Highway Department, has resigned to accept a position in the headquarters office of the California State Highway Department.

Carl E. Haydon of Sherman, Tex., has been appointed city engineer of McKinney, Tex.

Roy A. Murray, Promotion Secretary of the Y. M. C. A. at San Francisco, has been appointed secretary of the California Highway Commission to succeed John F. Galvin, of Richmond, who resigned to become a member of the State Civil Service Commission.

F. J. Nettleton has been appointed county engineer of Sheridan County, Kansas, to succeed A. J. Mowry, resigned.

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

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Vol. LXII. June 14, 1922 Number 24

TABLE OF CONTENTS

*A Trip Over the Storm King Highway 321
Portland Cement Concrete Roads. By James Allen 324
States Aid in Eliminating Railway Grade Crossings 326
Low Bid for Grading in South Dakota 326
New Bridge Is Opened in Indiana 328
Indiana Roads Ready for Tourists 328
Careless Drivers Named "Flivverboobs" 328
Effect of Organic Matter in Concrete To Be Studied 328
Funds Available to Build 46,000 Miles of Good Roads 328

EDITORIALS:

State Should Patrol and Light the Storm King Highway 327
Financing Our Future Highways 327

EQUIPMENT—TRADE—MATERIALS:

The Mile-a-Week Road Builder 330
New Steam Scarifier 330
Congress May Define a "Trade Association" . . 330
Saving the Nine-Foot Road 331
Cletrac Makers Expand 331
Brick Road Contract Let in Illinois 331

MEETINGS:

Calendar 332
A. A. E. Holds Annual Meeting 332

PUBLICATIONS: 329

PERSONAL MENTION 332

*Illustrated Article.

Concrete Roads must be Reinforced

It is demonstrated beyond doubt that to make concrete roads proof against heavy motor traffic, weather and time a fabric of steel must be incorporated in the concrete.

Several great States have so ruled.

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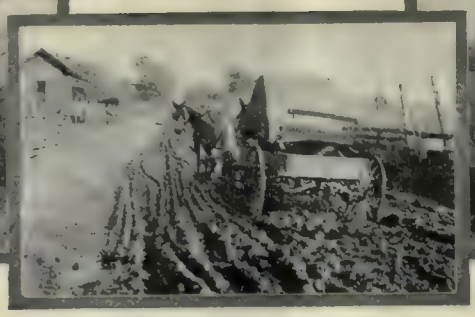

Typical Spring condition of soft-surfaced roads

Carthage-Antwerp Road, N. Y.
Another Tarvia Highway

Glastonbury-Hartford Road,
Glastonbury, Conn. "Tarvia-X," 1915

State Road at Kittery, Me.
"Tarvia-X," 1912

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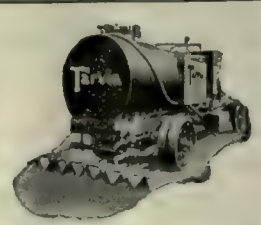

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GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

WITH WHICH IS INCORPORATED

THE HIGHWAY CONTRACTOR AND ROAD BUILDER

Vol. LXII. NEW YORK, N. Y., JUNE 14, 1922 Number 24

A Trip Over the Storm King Highway

History, Present Status and Details of Design of Highway Which Will Open Up the Highlands of the Hudson to the Motor Tourist

The history of the Storm King Highway dates back to a time shortly after the Civil War when a business man of Cornwall entertained the idea of building such a highway with private funds for a toll road. The need for it at that time was removed by the coming of the West Shore Railroad and nothing more was heard of the proposition until the New York State Highway Department made it part of their road building program. Various surveys and plans were made and a few yards of earth were excavated in 1907 on a contract which was subsequently cancelled. Work on the present contract was begun in 1915 and August 15 of this year has now been set as a tentative date for the completion of the new highway.

The highway is situated on the west bank of the Hudson River about 45 mi. from New York City and is 4.03 mi. in length. It begins at the end of Bayview Ave. in the village of Cornwall-on-Hudson and runs south around the nose of Storm King and Crow's Nest Mountains to join a state road already built at a point about one mile north of the Plains at West Point. It will cut approximately 20 mi. from the distance now necessary to cover to go from Cornwall to West Point by automobile. A further purpose was to provide a scenic route for motor tourists through the Highlands.

The cost of this work will run close to $1,000,000.

About one hour and a half from New York on the West Shore Railroad, Cornwall, N. Y., nestles down beneath the north side of Storm King Mountain and it is there that the famous Storm King Highway begins. The visitor catches his first glimpse of the road from the car window soon after the train emerges from the tunnel at West Point. By going out on the rear platform, we can follow the line of the road along the mountainside until the train rounds the nose of Storm King and the road far above is hidden by the overhanging cliffs. The train comes to a jolting stop at the Cornwall station and we transfer to a waiting Ford. Up the hill away from the river speeds our car and at the top of the hill about one quarter of a mile from the station, we turn sharply to the right. We are now going south on Bayview Ave., Cornwall-on-Hudson. Perhaps another quarter of a mile, and we come to the zero station of the Storm King Highway. This point is directly at the foot of the mountain and from it the road runs south and a little east along the side of the slope, gradually drawing nearer to the river. There is a little white house here, which is being remodeled into a tea room for the tourists of the future, and we are told that it is so close to the side of the mountain that the sun never shines on it from October to May.

There is a gate across the road but it is open to the battered flivver of Theodore Fenner, State Highway Engineer in charge, in which we are riding. Almost at once, our attention is drawn to the rustic guard rail and we stop to inspect it.

This railing is constructed of chestnut logs which were cut on the mountain. The bark is scraped off both rails and posts before they are put in place. The posts and top rails are 8 in. in diameter and the lower rails are 6 in. in diameter. The posts are spaced at intervals of 8 ft., the rails are 16 ft. long, and the splices on the top and bottom rails occur on alternate posts. The lower rails are bolted to the front of the posts. The top rails are set on top of the posts, spiked, and further held in place by iron straps, ⅛ by 2 by 40 in., which are spiked to the front of the post, run up and over the rail, and are spiked again on the back of the post. The portion of the posts which is below ground is charred before they are placed. This guard rail is approximately 4 ft. high and is to be treated with crude oil which will act as a preservative without destroying the rustic effect.

We climb back into the car and are once more on our way. The road on which we are riding is foundation course which was placed in 1921. This course is 5 in. of No. 4 broken stone (to pass a 3½ in. screen) rolled and filled with screenings. Subjected to the snows of winter and the rains of spring, it is now a very good waterbound macadam road.

About 1,500 ft. from the beginning of the road, the foundation course ends and we bump off onto the rough grade. At this point, there stands a crushing plant, now idle, and the locomotive crane with 40-ft. boom which handled all the rock excavated on the north side of the mountain. At Sta. 19+33, the retaining wall begins and likewise the parapet wall.

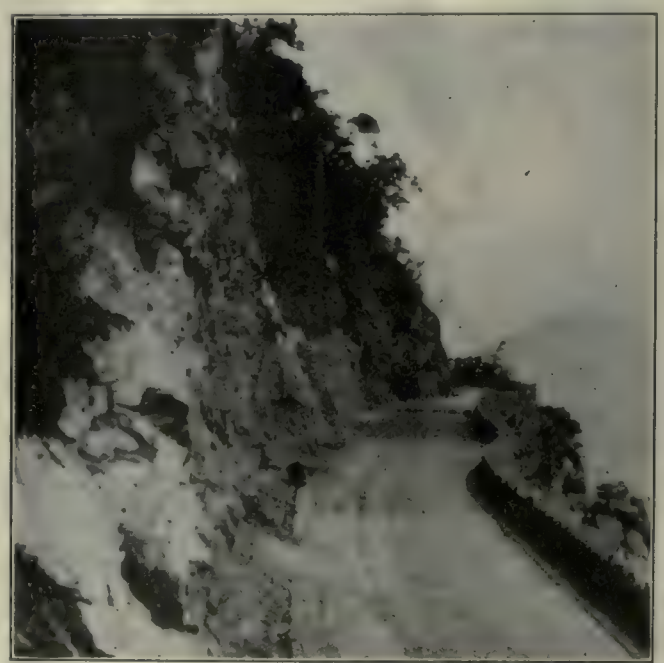
The retaining wall is dry rubble masonry and, standing at the end, we can see it well out to the nose of the mountain and note that it gradually becomes higher and higher. We are told, where it was deemed advisable on account of the height, this wall was laid on a masonry foundation. The parapet wall is a masonry wall 3 ft. high and 2 ft. thick and is topped with a dutch coping, rough pointed stones set on end, which adds another foot to its height. Mr. Fenner tells us that this coping was designed to prevent people sitting or walking on top of the wall. The parapet is pointed on the inside and contains tile drain sweepers every 10 ft. for drainage.

Once more back in the Ford, we roll along over the rough sub-grade, climbing about a five per cent grade, and do not stop again until we reach the summit of the grade. We are now standing on the point of the mountain at an elevation of 386 ft. and almost directly over the railroad tracks which skirt the bank of the river. As the Hudson is approximately sea level, we can say that we are 386 ft. above the water. The road curves to the west and follows the precipitous sides of the mountain away from the river.

This point is an almost perfect spot from which to view the most beautiful section of one of the most beautiful rivers in the world. Directly opposite us across the river and dropping down to the shore as abruptly as does Storm King, is Breakneck Mountain. To the north the river widens into Cornwall Bay and close to the eastern shore is the picturesque Bannerman's Island Arsenal. Further north, about five miles we are told, rise the many church spires of the city of Newburgh on the west shore. On the east shore is Mount Beacon with its incline railway leading to a cluster of white buildings on the summit and, between the mountain and the river the city of the same name. Away to the north the foothills of the Catskills may be seen and a break in the range which forms the horizon to the northeast is pointed out to us as Lake Mohonk.

Turning about to the south, our eye follows the line of the road along Crow's Nest and South Crow's Nest until, at a point about three miles distant, the road disappears around the mountain to the west, the river turns abruptly to the east, and directly in our line of vision we see the plains and the grey towers of West Point.

Mr. Fenner, to whom the view has become a thing of no great moment, calls us away from it to note the height of the cut. The top of the slope is, in some cases, 75 to 100 ft., measured on the slope, from the roadway. The next 1,500 ft. is the most interesting of the whole project and we choose to walk. We are headed east now and a little south into what is known as the "Big Gully," the valley between Storm King and Crow's Nest. Here we find the heaviest cut, the steepest slopes and the highest retaining wall and it is here that the work was the most dangerous. At the foot of the mountain is the plant of the Storm King Stone Co. now dismantled and buried by the mass of stone blasted down upon it. We are shown the point where the retaining wall is over 30 ft. high and are told that this section is mortar wall on a 12 on 1 slope instead of dry wall on a 6 on 1 slope, as elsewhere. At this point there is a peculiar looking curve and our guide explains that the road had to be moved in towards the mountain very abruptly because no adequate footing for the retaining wall could be found on the curve as originally planned and started.



RETAINING AND PARAPET WALLS, PAVED SHOULDERS AND FOUNDATION COURSE ON STORM KING

As we leave the side of the mountain and turn to the South, the Ford once more takes up its burden. The way leads through earth and boulders and out upon the fill over the gully which gives the whole valley its name. This gully must be 50 or 60 ft. deep and perhaps 200 ft. wide. On the far side of the gully is an immense borrow pit from which thousands of yards of earth were taken to make the fill. It is up to grade now and wide enough for us to drive over but still a little shy of the required width of roadway. More borrow excavation must be made here.

The stream which flows down the gully is carried under the fill by a 10x12 culvert. This culvert has masonry side walls with concrete slab and we are told that all the culverts on the job are so constructed.

A short distance beyond the gully, we run into a mud hole and Mr. Fenner explains that sub-base is to

be laid before the macadam can be placed. From the mud hole, we come to more foundation course similar to that at the beginning of the road except that here it is 6 in. in depth. We are now running through a hemlock grove and gradually approaching the river again. As we turn around the nose of the mountain, we come once more into rock cut. We have completed the swinging curve through the "big gully" and are close to the shore as we turn and head south. Here, at about Sta. 90, we come upon a gang laying foundation course and four masons laying paving. We stop to view the work and Mr. McGovern, inspector of masonry for the State Highway Dept., explains the paving to us.

The macadam in the sections in rock cut on the two mountains is 19 ft. wide, the roadway 24 ft. There is 2 ft. of paving between the parapet wall and the macadam and 2 ft. of paving at the other side of the macadam. The other foot on the inside is to be a ditch. The paving is 6 in. deep and is made of rough local stone hewn to the required shape with the masons' hammers and laid with the flat side up in dry mortar. After it is in place, the paving is grouted. These paved shoulders slope very slightly away from the macadam so that the water will run off and the paving on the wall side is flush with the weepers in the parapet wall. This paving was used instead of concrete shoulders because of the quantity of local stone available.

RUSTIC GUARD RAILING NEAR WEST POINT

After thanking Mr. McGovern for his explanation, we are once more on our way. The road parallels the river for 2,000 ft. and then swings out and around the point of Crow's Nest. The point juts out into the river and the road is almost directly over the railroad tracks, the cut very heavy, and the retaining wall high. After leaving Crow's Nest, there is no more rock cut in any amount. The road winds through a field of immense boulders which have rolled down from the mountain top through years past and Mr. Hayes, the contractor, tells us that the excavation of these boulders gave him more trouble than the excavation of solid rock.

Mr. Fenner points out the line where West Point government reservation begins and soon after, we come to an abrupt turn where the road leaves the river and runs southwesterly along the side of Target Hill to join the West Point-Central Valley state road. The turn is about 3,000 ft. from the end of the road. Here we find a second crushing plant, this one running full blast. The rock is being quarried out of the side of the hill a short distance away and is hauled to the crusher in dump cars by a compressed air hoist. Motor trucks carry the No. 4 stone to the point in the middle of the road where foundation course is being placed and the smaller sizes to the end of the road where they are laying top course. We learn that the foundation course on the 3,000 ft. between the end of the road and the crusher was laid in 1921.

As we leave the crusher behind us, Mr. Fenner tells us that the elevation here is higher than on Storm King and we find it very hard to believe. To anyone riding over the highway, this deception in regard to the height is one of the most remarkable features.

We soon come upon the gang laying top course and are interested in the pressure apparatus for spreading the bituminous material which they have mounted on an old truck and also in the gasoline road roller.

The top course is laid according to the general 1914 specifications of the New York State Highway Department for bituminous macadam, penetration method. No. 3 broken stone (to pass a 2¼ in. screen) is spread on top of the foundation course and rolled. The hot bituminous material is then applied under pressure to the amount of 1¾ gal. per sq. yd. No. 2 stone (to pass a 1¼ in. screen) is immediately spread on and rolled into the voids. After this course has set, the seal coat is applied to the amount of ½ gal. per sq. yd., covered with No. 1 stone (to pass a ⅝ in. screen), and rolled.

As we leave the road to ride to the station at West Point, Mr. Fenner sums up the situation for us. There is about 1.5 mi. of foundation course to be laid this season and practically the whole 4 mi. of top course. He thinks that the road will be completed early in August.

The South Dakota State Highway Department issues cards which give detailed information in regard to the time of opening bids. Each bid is scheduled to be opened at a certain time during the day and the contractor is thereby saved from wasting an entire day waiting for the bids in which he is interested to be reached.

Portland Cement Concrete Roads*

By JAMES ALLEN†

The selection of a type of pavement for our rural highways is a comparatively modern problem. Prior to the period of 1905 to 1910, there were but few rapid moving vehicles and these were confined largely to our city streets. The automobile, from the city man's plaything, has rapidly developed into a necessity. The highways with gravel or macadam surfaces were entirely adequate for the horse drawn traffic and easily and cheaply maintained, and the paved streets of the cities cared for both classes of traffic in a satisfactory manner.

As the automobiles became more numerous and traveled farther, with fair assurance that the return trip could be made without going to the repair shop, their usefulness increased and they changed from an experiment to an essential part of the world's transportation system, supplementing the railways, but none the less important. The tremendous increase in the automobile with its destructive forces soon forced those in charge of the highways to seek for the highway that would be smooth, safe and economical. The business of farm and city grew to be dependent on the automobile and the highway, and the city dweller and the farmer became insistent that the highways be paved.

A new problem confronted the engineers, not many of whom realized that the conditions were much different than those surrounding the paving of a city street. It is well recognized now, however, that the character of traffic changes from comparatively slow moving vehicles evenly distributed over the width of a city street to rapidly moving vehicles concentrated into two lines of traffic on the highway. The destructive forces set up by this high speed traffic have been studied and we are now measuring the forces that destroyed many of the earlier highway pavements; forces that all practical engineers recognize and prepare for in their designs. All known types of pavement and many that were unknown have been tried on the highways.

Perhaps the first made of concrete were built by the Romans who used a natural cement. The city of Edinburgh, Scotland, built a concrete pavement in the year 1872, and I understand that it continues to give good service. Concrete was first used on this continent by the city of Bellefontaine, Ohio, for paving the court house square in 1892 and 1893, and the pavement is now in a satisfactory condition.

The year 1909 saw the first development of the Portland cement concrete pavement as a rural highway. Its use has developed until today it is almost universal.

The United States Government has appropriated $350,000,000 to aid states in rural highway development. The report of the U. S. Bureau of Public Roads covering the period from 1916 to November 1, 1921, shows that, of all the highways paved, 4,654 mi. or 79.3 per cent were paved with Portland cement concrete. Those states having the greatest population and the heaviest traveled highways have practically all selected one course concrete pavements as their standard. The states of New York, Illinois, Pennsylvania, Ohio and California construct several hundred miles of concrete pavement each year.

The first highway paved with concrete in the State of Washington was in 1912, and although crude in design and construction as compared with present day standards, it is still in use and giving satisfaction. Since then the counties and state of Washington have constructed approximately 800 mi. of concrete pavement. No other type is constructed for the state, for we believe that a Portland cement concrete pavement properly constructed is the best pavement. This position is justified by the first cost of the pavement, the service that it renders and the cost of upkeep. The first cost of concrete pavements is less than brick and about the same as the best type of bituminous pavements. We believe that the service rendered by the smooth, non-slippery surface of a concrete road is superior to all other types and that the cost of upkeep is far less.

In order that a paving program may be a success, a definite highway system, designed to serve the majority of the people, must be selected, adhered to and built up by a continuing program covering a period of years. If the routes are not well selected, they must later be changed and the money spent on abandoned sections will serve for local purposes only. The people will get along with the longer poorly selected highways for a few years, but it is ony a matter of time before a demand will develop for the most direct and practical route from the point of view of the motor vehicle operator. A highway must be safe, and it must serve the majority of the people and not the few who may reside off of the proper alignment. The location of a highway to secure the best route that the terrain affords, the most economical route, cost of operation and maintenance considered, is just as important as is the selection of a route for a railway, and it deserves the same thorough study. Unnecessary distance and unnecessary grades are an indirect tax on the people by reason of the increased operating costs. It is also essential that the grade be contructed and permitted to settle before a pavement is constructed thereon.

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*Paper presented at the convention of the Canadian Good Roads Association, Victoria, B. C., June 12 to 15, 1922

†Supervisor of State Highways, Olympia, Wash.

Before a highway is paved in the state of Washington it must be graded and allowed to settle for at least two years.

A pavement is a slab supported by the earth subgrade and in a broad way the four things to be considered in the structural design of the pavement slab are (1) the supporting power of the subgrade, (2) the climatic conditions, (3) the traffic that the pavement slab must carry and (4) the strength of the pavement slab.

A good subgrade must be constant in volume, homogeneous in character and have a supporting power on which the design can be based. Many soils undergo a change in volume with the addition or subtraction of water, thereby changing the points of support of the pavement. If the soil increases in volume near the edge of the pavement only, the upward thrust will introduce unusual stresses in the pavement. Or if the soil, by reason of the loss of moisture, shrinks near the edge of the pavement, leaving the pavement unsupported, the wheels of traffic will break down this edge until it is supported by the soil. If a subgrade is not constant in volume, the design must provide for the change in the position of the support afforded the pavement. By a homogeneous subgrade, I mean a subgrade that is uniform in character. Soft spots or unusually hard spots are harmful. The pavement must be uniformly supported in order that the stresses may be equalized and distributed in all directions in the slab. If they are concentrated by hard or soft spots in the subgrade, the pavement must fail first at these points. A subgrade constant in volume and homogeneous in character must also have definite supporting power on which the design of the slab may be based.

There is, perhaps, no subject that has been written of and spoken of so often and neglected so much as the subject of drainage. The surface and ground waters must be removed away from a pavement if the pavement is to last. This is particularly true if the frost penetrates the ground more than six or eight inches. The upheaval of pavements due to frost action is a very common occurrence and one of the seriously harmful agencies to be understood and cared for. Good drainage and a thorough understanding of climatic conditions are necessarily a part of the success or failure of a pavement. Changes in the temperature of the concrete slab and changes in the moisture in the concrete develop forces that are to be provided for and worked with, rather than resisted. The natural force as well as the forces of traffic must be studied and met in pavement design.

It was little thought fifteen or twenty years ago that the volume and character of traffic on our modern highways would change so tremendously. The number and size of vehicles grew by leaps and bounds, as also did the loads that they carry. The five or seven passenger car grew to a twenty or twenty-five passenger bus; the one-ton truck to the huge freight and logging truck of today. It seems, however, that this growth must be, and in fact it is, being controlled by legislation in the interest of the limit on our financial ability to construct pavements to withstand the loads. Without legislation to control the maximum sized truck and the distribution of its weight upon the pavement,, it would be impossible to maintain our highways and reap the benefits to which we are entitled by reason of the public funds invested in the highways. Pavements, of course, can be built to withstand any given load, but the funds needed to pay for them would bankrupt our people. I suggest that the load be limited to 18,000 pounds to any one axle and that the vehicle having four wheels be limited to 12 tons. In studying this subject, the causes of and the amount of impact must be known. Tests have been made along this line that have demonstrated the value of pneumatic and solid rubber tires and the much greater impact with solid rubber tires as compared with pneumatic tires. While the volume of traffic is important, its character is vital, and the loads must be thoroughly studied.

Pavements first developed through cut and try methods. They were designed in so far as their general makeup was concerned, but the stresses in the pavement slab were not calculated. The problem, being one of mechanics, involving a multitude of stresses acting from below as well as from above, justifies a vast amount of research work that is now being attacked in a scientific manner. The technical data developed regarding the character and impact of traffic and its effects on the pavement, the supporting power and reactions of the subgrade, the distribution and variations of the subgrade reaction and the stresses in the various parts of the pavement slab are technical and too involved to be discussed at this time. Progress in research is very rapid and, while it is improbable that we shall ever develop short formulae that will be adequate, it nevertheless will be possible to design an adequate and economical pavement after a thorough study of the subgrade, the traffic and the materials of which the pavement will be made.

The ordinary defects found in concrete pavements are broken corners and cracks, both longitudinal and transverse. Pavements so obviously inadequate because of design, faulty materials or faulty construction as to ravel and break down completely, are not considered here for the reason that this condition can be avoided without any great difficulty. Broken corners, having a length along either leg or two or three feet are serious and should be avoided by a proper thickness of slab. The corner of a slab or section of pavement has been demonstrated to act as a cantilever beam and can be designed as such, considering the maximum wheel load, impact, and the strength of the concrete. This calls to mind again the necessity of limiting the wheel load to a given maximum as a basis for design. A pavement designed to have sufficient

corner strength to carry a certain traffic will be adequate as far as shearing or punching strength at other points is concerned. Transverse and longitudinal cracking cannot be so easily eliminated. These cracks are caused by stresses due to beam action in the slab, unequal expansion and contraction, due to moisture and temperature changes, frost action and unequal support afforded by the subgrade. The subject is being studied and the question arises as to how far we shall go in expense to avoid cracks altogether. At first a crack was thought to be a sign of incipient failure. Experience has shown, however, that from a maintenance and operating point of view they are not fatal; it is still a matter of opinion as to how serious they are.

There are many pavements eight to ten years old that are badly cracked and they continue to give good service, at a comparatively low cost for maintenance.

Sand is "just sand," and gravel "just gravel" to the average man. To the engineer, however, they are an important part of his work and must be thoroughly tested to determine their fitness for concrete construction. It is also necessary to test the cement and the water proposed for use in concrete construction. The possible sources of sand and gravel should be thoroughly examined before the contract for a pavement is awarded. The examination should include test holes to determine the quantity of materials available, and the sand and gravel should be thoroughly tested to determine their suitability or the possibility of washing and regrading to make them satisfactory. This information, if available to contractors, will eliminate the most extreme and risky gamble connected with pavement construction. It is also advisable to acquire the property for the development of side of the road pits, as the municipality is in a better position to purchase the land from which the sand and gravel are to be taken than is the contractor. If the property is made available to the bidders by the organization awarding the contract, all bidders are on the same competitive basis; if, on the other hand, one contractor should acquire the property to the exclusion of all others, he can exploit his position for his personal profit, a condition that means increased costs of construction.

Good workmanship must go hand in hand with good materials. The one is just as essential as the other to a good job. We have developed a system of carrying on and finishing our work that has eliminated the personal equation to a large extent. Each contractor is required to furnish a definite set of tools designed by the state and to use them in a certain prescribed manner. Each workman is thereby given the benefit of the experience of all by being supplied with tools and instructions from our engineers and they secure a first class job.

The specifications covering the details of materials and construction are quite thoroughly developed, and, under competent engineers, are getting good results. From a layman's point of view and from an administrative point of view, the thing to do is to secure the services of competent engineers and then to back them up. Specifications are only as good as the inspection. Furthermore, no matter how good the specifications, their value to the work is measured by the loyalty, intelligence and judgment of the engineers and inspectors in charge of the work and the support given them by public officials and the public at large.

STATES AID IN ELIMINATING RAILWAY GRADE CROSSINGS

What can be done when a community sets out to rid itself of the menace of railroad grade crossings is shown by the plans for a federal-aid road to be constructed in Alabama between Ariton and Clayton. In a distance of about 25 mi. the old road crossed the railroad 14 times. By good engineering 13 of these crossings have been eliminated, the remaining one being in the small town of Clio, where there are only three trains a day, and these move at slow speed as they approach the station.

Some months ago the U. S. Bureau of Public Roads announced that grade crossings would be eliminated on all federal-aid highways wherever practicable. Officials of the bureau are receiving hearty co-operation from state highway departments and the general approval of the public.

It has been found possible to revise many plans, keeping the road entirely on one side of the track or finding a suitable place where the road can cross beneath or above the track.

In some states the highway department on account of existing legislation are having difficulty in inducing the railroad companies to share the cost of placing the highway above or under the track.

LOW BID FOR GRADING IN SOUTH DAKOTA

What is said to have been the lowest price received for grading in the history of the South Dakota State Highway Department was received recently when a contractor bid 15 ct. per cu. yd. for an extensive project in Spink County. That figure includes all grading, the finishing of the road, and its maintenance until it is finally accepted by the commission. In Clark County another low bid of 19 ct. per cu. yd. was received. At these prices the commission can build from 2 to 2.5 mi. of road for the price of constructing 1 mi. in 1920.

The Lincoln Highway Condition Report, the first for the 1922 touring season, was issued May 15. These reports, which give a complete picture of conditions on the Lincoln Highway, will be published twice monthly by the Lincoln Highway Association until November 15. Through them the press, the representatives of the association, and tourinng bureaus everywhere are provided with reliable information for tourists.

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

Founded January, 1892

E. L. POWERS
Editor

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Copy for advertisements must reach the New York office by noon on Tuesday of the week before date of issue if proofs are to be submitted.

Copy for classified and other advertisements where proofs are not required will be accepted until noon on Monday of the week of issue.

Articles by road builders are solicited. They should be short and, if possible, accompanied by photographs. Those accepted will be paid for at current rates.

Vol. LXII. June 14, 1922 Number 24

STATE SHOULD PATROL AND LIGHT THE STORM KING HIGHWAY

There is one fact that cannot fail to impress itself upon anyone who makes a trip over the Storm King Highway as described elsewhere in this issue. That fact is that it is going to be a very dangerous stretch of roadway. In order to follow the slope of the mountains, it was necessary to build a road of many curves and many changes of grade. As the cut was in solid rock and very heavy, it was not possible to provide for proper vision on these curves, either horizontal or vertical. Therefore, it will be a place for slow and cautious driving.

While a great many will be sufficiently awed by the great heighth of the road above the river to proceed carefully and many more will want to drive slowly so as to get the full benefit of the view, there will always be some who will take chances. To protect the touring public from these reckless drivers, it seems that the road should be patrolled by traffic policemen during the day and should be lighted at night.

It was originally planned to have the road widened at certain points where the tourists would be most likely to stop but this was not found to be practicable. As the road will be only of ordinary width, it is probable that the traffic will become so congested at times that traffic policemen will be needed to keep the two streams of travel moving.

The need for both patrolmen and lights is further emphasized by the fact that the formation of the rock on the mountains is such that pieces of ledge break off and roll down the mountainside. The railroad at the foot of the mountain has found it necessary to have watchmen on duty twenty-four hours a day to guard against this danger and there is no reason why some like precaution should not be taken with the highway.

Aside from the protection they would afford the automobilist, lights along this highway would serve to advertise it better than any pamphlets or other publicity matter. They would attract the attention of travelers on the Hudson River night boats and on the railroads on both sides of the river, and thus announce to people from all over the world the existence and location of this wonderful highway the State of New York has built for the delight of all tourists.

FINANCING OUR FUTURE HIGHWAYS

"Plan now the financing of highways for the future and place highway transportation, which has come to be an indispensable part of our national life, on a firm foundation." This is the advice given by Thomas H. MacDonald, Chief of the U. S. Bureau of Public Roads, for the consideration of every voter, tax payer and legislator.

"We are starting out to construct a system of highways such as no nation ever constructed before. The nearest approach to it is found in France and Germany, and the area of neither is as large as Texas. This great undertaking is being entered into because highways are not a luxury but furnish a real service, have a real earning capacity, and have become a national necessity.

"For such an undertaking to be successful, financing to care for maintenance, reconstruction, and new construction should be planned for a long period of years in advance. Changes in methods of raising funds every few years, uncertainty as to whether funds will be provided, and periods in which funds are not provided all increase the final cost of highways. Such a policy would soon bring any private business to disaster.

"Development and increase in numbers of motor vehicles and the coincident need and demand for good roads have come so rapidly that methods of raising funds have often been expedients for the time being. Consideration has been given not so much to the just distribution of the cost as to how the funds can be raised with the least controversy and the utmost ease. Then, too, the use made of highways and the service rendered by them has changed greatly within the last few years.

"All this leads to the conclusion that the whole situation should be gone over very carefully, traffic studies made, and the cost distributed in proportion to the service rendered.

"The Bureau of Public Roads estimates that of the $600,000,000 spent for highways last year 33 per cent

was federal aid and motor vehicle revenue. The remaining 67 per cent comes either directly or will eventually be paid from state and local taxes. It is believed that a very considerable readjustment of the source of revenues must be made so that a larger percentage will be paid by the road user and a lesser percentage from state or local taxes."

NEW BRIDGE IS OPENED IN INDIANA

The new concrete highway bridge over the Wabash River at Attica, Indiana, was recently opened for use with appropriate dedication ceremonies. This bridge, which was built by Fountain County under state supervision and after state plans, was started in August, 1919, cost about $273,000, and is the largest in the state. The total length of the bridge is 985 ft. The six spans vary in length from 150 to 135 ft. The roadway, which is 40 ft. above the low water line of the river, is 20 ft. wide and is flanked on either side by 5-ft. sidewalks. The structure is lighted by electricity.

INDIANA ROADS READY FOR TOURISTS

The maintenance division of the Indiana Highway Department made haste this season to get the state roads in condition so as to take care of the traffic to and from the Indianapolis Motor Speedway for the motor derby of May 30. According to John D. Williams, director of highways, all the trunk lines are in splendid condition. The highways are marked with numbers painted on the telephone poles, white numbers on a black background within an outline drawing of the state. To insure the maximum safety of all drivers unfamiliar with the roads, culvert headwalls, mail box posts, telephone poles, and other obstructions near the roadway have been freshly whitewashed. The publicity department keeps the neighboring state highway departments, chambers of commerce in the cities of Indiana and the surrounding territory, and automobile and motor clubs informed of the condition of the interstate routes.

CARELESS DRIVERS NAMED "FLIVVERBOOBS"

Reckless and careless drivers of automobiles are to be known as "flivverboobs" according to the decision reached by the judges of the American Automobile Association's contest to pick a name describing the reckless driver in the same manner that "jay-walker" describes the careless pedestrian. More than 10,000 names were submitted by contestants from all parts of the country. The winning name was suggested by F. B. Simpson of Cedar Rapids, Ia., and the prize of $25 in gold offered by the A. A. A. has been forwarded to him.

Secretary of Agriculture Wallace has just approved the expenditure of $586,000 of national forest highway funds for the construction of 106 mi. of roads in the State of Colorado.

EFFECT OF ORGANIC MATTER IN CONCRETE TO BE STUDIED

Sands unsuitable for concrete on account of the presence of loam or other organic matter are to be investigated by the U. S. Bureau of Public Roads and methods of treatment devised to make them safe for use. Until recent years it often happened that concrete made of good cement and well-graded and apparently good sand, would disintegrate and become worthless. In such cases the poor quality has been attributed to all the different things which go to make a poor concrete. A few years ago laboratory workers discovered the effect of organic matter in sand and devised a simple test to determine its presence in harmful quantities. The bureau now hopes to find methods of treatment so that such sands can be used. Samples of sand from all parts of the country are desired and anyone is invited to send in a sample in which the presence of organic matter is suspected, addressed to the Bureau of Public Roads, Washington, D. C.

FUNDS AVAILABLE TO BUILD 46,000 MILES OF GOOD ROADS

The $350,000,000 appropriated by Congress as federal aid in conjunction with state funds will result in the construction of about 46,000 mi. of road, says the U. S. Bureau of Public Roads. This mileage would parallel the railroad from New York to San Francisco nearly 15 times, or, if divided equally among the States, would give nearly 1,000 mi. to each State.

The status of road building on April 30 was as follows: in projects entirely complete, a total of 16,375 mi.; under construction, 13,950 mi. in projects, averaging 62 per cent complete. A considerable part of the latter mileage is actually complete and in service. In addition funds have been allotted to 7,511 mi., much of which will come under construction during the present season. Besides this there is still available for new projects $60,148,000, which on the same basis as previous Federal-aid construction will result in the construction of 8,200 mi. of highway. In March the fund available for new projects was taken up at the rate of $12,000,000 a month and at the rate of $5,700,000 in April.

A movement is under way to plant thousands of Iceland poppies along the road from Calgary to Banff in the heart of the Canadian Rockies. Automobile clubs are cooperating in the movement and it is planned to use 60 cars, each containing four men, to prepare the soil and do the planting. One car will be assigned each mile of road.

The Montana State Highway Department has exercised for the first time the authority vested in it by the last legislative assembly by ordering the removal of an objectionable advertising sign along a state highway. The sign obscured the vision at a railroad crossing.

PUBLICATIONS

PUBLICITY METHODS FOR ENGINEERS. Cloth, 5½x 7¾ in., 207 pages, 65 illustrations. Published by the American Association of Engineers, 63 E. Adams St., Chicago, Ill. Price $1.50, postpaid.

This book is based on the papers and discussions at the First National Engineering Conference on Public Information, 1921. It has been carefully edited to conserve the time of the reader and amended to make a working manual of modern public information methods used by associations, societies, municipalities, public service corporations and trade organizations in promoting favorable public opinion rather than commercial products. The methods used by the American Association of Engineers are discussed in detail.

The contents include six chapters: (1) Some Reasons for Publicity, (2) The Right Conception of Publicity, (3) Ways and Means that Bring Publicity, (4) Getting News in the Newspapers, (5) The Publicity Man and What He Needs to Know, (6) Typical Publicity Problems, and an appendix; (1) Some Approximate Costs for Estimating, (2) A Brief Outline of a Working Plan.

In addition to giving the principles of presenting to the public information about engineers, this book shows by specific examples how it is being done at the present time. While it is described on the jacket as a manual for men engaged in publicity work, it can not fail to be interesting and valuable reading for any engineer, especially one employed on public works.

HENDRICKS' COMMERCIAL REGISTER. 1921 edition. Cloth, 7¼ by 9¾ in., 2,572 pages. Published by S. E. Hendricks Co., Inc., 70 Fifth Ave., New York City. Price $12.50.

This volume is a register of producers, manufacturers, dealers and consumers connected with the electrical, engineering, hardware, iron, steel, mechanical, chemical, architectural, mill, mining, quarrying, contracting and kindred industries. It is intended as a buyers' reference for the use of executives, purchasing agents and sales managers engaged in the above industries.

The book is divided into five sections: (1) Index to Trades, (2) Classified Trades, (3) Trade Names, (4) Alphabetical, (5) Index to Advertisers. The first section is an index to the second which lists the concerns under the material or service offered. In the larger lists, the arrangement is alphabetical by states and cities, and in the other lists, is alphabetical for the whole United States. The third section lists trade names followed by the name and address of the manufacturer. In the fourth section, all firms which appear in the book are listed alphabetically.

ENGINEERS' LICENSE LAWS. Paper 6x9 in., 136 pages. Compiled by the American Association of Engineers, 63 E. Adams St., Chicago, Ill. Price 50 cts., postpaid.

This is a compilation of exact copies of the license laws for professional engineers in various states, and it contains sixteen laws now in force in sixteen states: Arizona, Colorado, Florida, Indiana, Iowa, Louisiana, Michigan, Minnesota, New Jersey, New York, North Carolina, Oregon, Pennsylvania, Tennessee, Virginia, West Virginia. It has been prepared and published as a service to the profession, for the use of engineers who desire to practice engineering in more than one state, and also for the assistance of those engaged in the preparation of a law in states where engineers are not registered.

NEW PUBLICATION ANNOUNCED

The Department of Roads and Highways of Kentucky has announced for this month the first issue of a monthly publication to be called the "Kentucky Road Builder." Joe. S. Boggs, State Highway Engineer, will be editor and the magazine will be published by John H. Hoagland, 514 S. 5th St., Louisville. The purpose of this publication will be primarily the education of the people as to the work and accomplishments of the highway department.

HIGHWAY DEPARTMENT TO PUBLISH INSTRUCTION MANUAL

The State Highway Department of Montana contemplates the completion in the near future of a manual of instructions for employees. The manual will be divided into three sections dealing with administration, preconstruction, and construction respectively. The administrative section, which deals with headquarters and district office procedure, is now complete. Principal Assistant Engineer H. C. Kuhl is engaged in compiling the preconstruction and construction sections which will deal with field and office engineering practice. It is the intention of the department to have the manual printed in loose leaf form and bound in ring binders of convenient pocket size. This plan will permit of revision as future changes in practice require.

CONEY ISLAND PARKWAY COMPLETED

Ocean Parkway from Prospect Park to Coney Island in the Borough of Brooklyn, N. Y., has been paved to a width of seventy feet with 3 in. asphalt top on a 6-in. concrete base and was formally opened to traffic May 19. This section of road is about 5.5 mi. in length and was built at a total cost of $1,030,785. That the work was pushed very rapidly is shown by the fact that the appropriation was not voted until March 19, 1921. The parkway is one of the finest, if not the finest, thoroughfare in Greater New York.

Approval by the U. S. Bureau of Public Roads, of the plans submitted by the State Highway Commission of Indiana for the ideal section of the Lincoln Highway to be built in Lake County, near Chicago, now makes it possible for the State of Indiana to proceed immediately with the construction of the section.

Equipment — Trade — Materials

DUNN ROAD PAVER IN OPERATION

THE MILE-A-WEEK ROAD BUILDER

The Mile-a-Week Road Builder is the name given to a new machine for screeding, tamping, and finishing concrete roads manufactured by the Dunn Road Machinery Company of Conneaut, Ohio. Although the machine has not been advertised previous to 1922, the first one was built seven years ago. Many miles of roads were tamped and finished during this pioneer period. The machine is arranged for tamping and belt finishing concrete roads and is adjustable for base courses and for two-course concrete pavements. In the latter case, a sub strike-off is used. It is dropped in front of the machine by means of a self-locking lever and strikes off the first course at any required distance from the top of the forms. This makes it possible to locate the reinforcement exactly as specified.

When put in operation the machine strikes off the concrete in two levels. The auxiliary strike-off is the first member to come in contact with the concrete as delivered from the mixer. It allows about a 2-in. layer to pass under. This layer is then operated upon by the clearing tamper which has an adjustable vertical movement and comparatively slow speed. Through its action all large pieces of aggregate are pressed slightly below the finished surface. The main strike-off follows the clearing tamper and, having to contend with only fine material, cuts clean and smooth with no tearing up of the surface. The concrete is next acted upon by the spader, a ⅜-in. blade suspended from the front end of five rocker arms. The tamper, a 4-in. channel with flanges turned up is hung from the rear end of the same rockers. Both these members have a vertical movement and are driven by eccentric cams. Both are adjustable as to depth of stroke and contour. The last step in the process is accomplished by the finishing belt. This has a 5-in. transverse stroke and can be lifted clear of the road, started and stopped by the operator who rides on a platform located in the middle and on the front side of the machine.

NEW STEAM SCARIFIER

A new steam scarifier for attachment to a Case road roller has been placed on the market this season by the J. I. Case Threshing Machine Co. of Toronto, Ont. It is attached to the rear of the roller and both are handled by the same operator. The six scarifier teeth are raised and lowered by a steam pressure cylinder and are driven into the ground by a pressure of four tons. The teeth are adjustable for depth and can be removed if desired. Thus depth and width of cut can both be varied. The attachment adds 1,850 pounds to the weight of the roller. The rollers with scarifier attachment are specially constructed with all steel bearings and spring cushions in the differential gear to absorb the sudden strains due to the additional work.

CONGRESS MAY DEFINE A "TRADE ASSOCIATION"

A joint resolution introduced in Congress by Senator Edge of New Jersey and Representative McArthur of Oregon provides for the appointment of a committee of three senators and three representatives to make a study of the legal situation affecting trade organizations and to recommend legislation "to define the rights and limitations of co-operative organizations as distinguished from illicit combinations in restraint of trade." Senator Edge introduced concurrently a bill defining the rights of trade associations.

SAVING THE NINE-FOOT ROAD

Nine-foot macadam roads are common in many parts of the country. How many miles there are figures do not show but personal observation leads to the view that the mileage is considerable and that 9 ft. of macadam is well worth saving if a way can be found to do it economically.

A sensible and inexpensive way of salvaging these old roads was undertaken by LaCrosse County, Wisconsin, and it proved to be wholly satisfactory. The road is called the Salem Road, Trunk Line No. 21, and the part that was rebuilt is about ten miles long, connecting with Federal Project No. 164.

The method of construction was as follows. On either side of the old road trenches were dug to the depth of the old macadam. In these trenches were constructed broken stone foundations. These foundations were, in reality, shoulders for the old road. They were built 4.5 ft. wide, so that the new roadway is now 18 ft. The material thrown out of the trenches formed a berme for the shoulders and for the new top. In all construction work of this kind it is extremely important that the new work be rolled thoroughly, so that there may be no settlement of the new part when the road is completed. Many failures of new topping may be traced directly to lack of care in rolling and thoroughly consolidating new bases placed contingent to old construction.

The illustration shows how the old road looked after the new shoulders had been built. The improvement was considerable, but the road was yet by no means a trunk line suitable for carrying heavy traffic. It was necessary to build a new top over the old road and the new shoulders. In cases of this kind it is sometimes advisable to let the road go through a season before the new top is put on, so that if there is any settlement of the newly built sections such settlement may be taken care of before the top is spread. But if the drainage is good, the sub-soil firm, and the shoulders have been well built there is no reason why the top may not be immediately laid.

In the case in question a 3-in. Tarvia-X penetration top was constructed as soon as possible after the foundation was completed. This was used as fast as it was built. While the shoulders were being built traffic used the old road, and with the rapid construction possible by the penetration method there was a minimum of discomfort to the traveling public. Wisconsin is noted for its opposition to detouring, and the methods used in constructing this 10-mi. road were such that no detours were necessary.

This method of using the old road as part of the foundation for a new and wider highway has so much to commend it that there should be more of it done. There is a direct saving of at least 50 per cent in the foundation cost; there is assurance of a perfectly consolidated base under the center of the road, and the shoulders may easily be made as firm as the old road itself; there is a good road for traffic to travel over all the time that construction is proceeding; and construction work is rapid.

CLETRAC MAKERS EXPAND

The Cleveland Tractor Co., Cleveland, Ohio, makers of Cletracs, will soon be reorganized as the Allyne-Zeder Motors Co. to manufacture and market the new six-cylinder car which is being designed by F. M. Zeder, formerly chief engineer of the Willys Corporation and the Studebaker Corporation. A new corporation subsidiary to the Allyne-Zeder Motors Co. will be organized under the name of The Cleveland Tractor Co. and will continue the marketing of Cletracs through its present distributors and dealers. A new one-ton truck, embodying advanced details of design, will be added to the Cletrac Line in the near future.

The Cleveland Tractor Co. is an Ohio corporation with a capital of $6,000,000. It owns a large plant in Cleveland where Cletracs have been turned out for more than five years. The present plant facilities will make it possible to proceed with the manufacture of the new Zeder with a comparatively small expenditure and without impairing the production program of trucks and tractors. The productive capacity of the factory will be 50 automobiles and 50 tractors a day.

BRICK ROAD CONTRACT LET IN ILLINOIS

The Illinois State Highway Department has just let the contract for the first brick highway to be built by the state under the present administration. The successful bidder was J. E. Craine of Murphysboro, Ill. The road is 13.32 miles in length and is situated between Cobden and Dongola. Specifications provide for a base of 10 in. of novaculite, laid in two 5-in. courses, a 1.5-in. sand cushion, 3-in. vitrified brick and asphalt filler. Curbs of compacted novaculite will be 12 in. wide and 4.5 in. deep. The pavement will be 18 in. wide.

"Novaculite" is a trade name for a local material found in southern Illinois which is a silica product, or what some engineers call disintegrated chert. It contains alumina and oxide of iron, commonly called "clay binder" and, when rolled and compacted, sets up hard with a cementing characteristic. Like crushed stone, slag or gravel where available, it is looked upon as a good base material when a rolled base is desired.

The Cobden-Dongola road is a portion of one of the principal north and south highways of the state which, starting at Decatur, runs due south through Pana, Vandalia, Centralia and Carbondale to Cairo, on the Mississippi River. When completed it will be one of the heavy traffic routes of the state.

The North Carolina Highway Commission has contracts for 1,000,000 barrels of cement to be imported from Sweden.

MEETINGS

Calendar of Coming Meetings

June 19-20—American Construction Council—Organizing meeting, Washington, D. C., R. C. Marshall, Jr. 1053 Munsey Building, Washington, D. C.

June 26-July 1—American Society for Testing Materials—Twenty-fifth annual meeting, Atlantic City, N. J. Secretary, C. L. Warwick, Engineers' Club Bldg., Philadelphia, Pa.

Aug. 9-10—Custer Battlefield Highway Association—Annual meeting, Sheridan, Wyo. Secretary, W. D. Fisher, Sheridan, Wyo.

Oct. 9-13—American Society for Municipal Improvements—Annual convention, Cleveland, O. Secretary, Charles Carroll Brown, St. Petersburg, Fla.

A. A. E. HOLDS ANNUAL MEETING

The failure to pass resolutions and constitutional amendments which would have materially changed the workings of the organization marked the annual convention of the American Association of Engineers at Salt Lake City, Utah, June 5, 6 and 7. The majority of the more than 100 delegates present favored stability and unity rather than innovations and changes which might disrupt the organization. The work of the meeting lay along the line of dividing the control of the body between the local chapters and the national headquarters.

One important action of the meeting was the authorization of an extended national employment service to be developed by the board of directors as soon as sufficient funds are available. An amendment to the constitution created a judiciary committee which will act as a court of final review on all cases, especially those involving ethics. The practice committee reported that it had passed on 20 cases in the past year. It had acted as a superior court but recommended the creation of a supreme court to pass on their findings. The report of the employment committee showed that one member in three had applied for employment during the year and that more than 1,100 men were placed by the chapters and 1,629 by headquarters. These figures indicate the need for an expanded employment service. Chapter functioning, publicity, and the importance of the engineer taking part in public affairs were discussed and a resolution passed urging the chapters to induce members to join civic societies and to seek appointment on committees relating to engineering.

Entertainment of the delegates included the inspection of various engineering works in the vicinity of Salt Lake City. A full-day trip by automobile took them over some of the fine paved roads of Utah and an inspection tour was made over the new road through Ogden Canyon.

The following officers for the ensuing year were elected: President, A. N. Johnson; vice-presidents, G. E. Taylor and A. M. Knowles; directors, B. W. Matteson, W. S. Boyle, W. M. Peyton, C. A. Poole, F. C. Shepherd.

PERSONAL MENTION

P. S. Altman has been appointed district engineer of the Portland Cement Association in charge of the Minneapolis office to succeed W. E. Hart who has been transferred to the general office as manager of the structural bureau. Mr. Altman has been connected with the association for the past 2½ years and prior to that time was in the corps of engineers, U. S. Army, and city engineer, Atchison, Kansas.

John B. Hunter, city engineer of Denver, Col., has resigned on account of ill health after serving 43 years in the city engineering department.

L. S. Trainor has been appointed district engineer in charge of the Illinois district of the Portland Cement Association to succeed C. M. Powell, resigned. The district office is located in the Conway Building, Chicago, Ill. Before he joined the association three years ago, Mr. Trainor was county superintendent of highways of Marion County and city engineer of Centralia, Ill.

Henry G. Shirley, County Engineer of Baltimore County, Maryland, and formerly State Highway Engineer of Maryland, has been appointed chairman of the new highway commission of Virginia. A native of West Virginia, Mr. Shirley was educated in private schools and received the degree C. E. from the Virginia Military Institute at Lexington, Va. He has been connected with the engineering department of the New York Central Railroad, district engineering department of the District of Columbia, the faculty of the Horner School, the West Virginia Coal and Iron Extension as assistant engineer, and the Baltimore and Ohio Railroad. His first connection with road work came in 1904 when he became roads engineer of Baltimore County. In 1912, he was appointed chief engineer of the Maryland State Roads Commission, a position which he held for six years. During the war, he represented the American Association of State Highway Officials on the Highway Transport Committee of the Council of National Defense and later became secretary of the Federal Highway Council. The appointment of county engineer of Baltimore County was secured after the Federal Highway Council suspended its activities.

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Vol. LXII. June 21, 1922 Number 25

TABLE OF CONTENTS

*The Bates Experimental Road Tests 333
The Effect of Initial Pavement Design upon Ultimate Cost. By Walter E. Rosengarten 336
California Obtains Convictions for Overloading . . 337
Virginia to Try Force 337
Ground Broken for New Tunnel 337
Three Year Federal Aid Program for Road Construction 338
Lower Prices for Various Highway Materials Reported 338
Motor Busses on Highways and their Relation to Rail Lines 341
Minnesota Highway Maps Gain Wide Distribution . 341

EDITORIALS:

A Story with a Moral 339
The Illinois Road Tests 339

EQUIPMENT—TRADE—MATERIALS:

Complete Unit Will Handle Concrete Road Materials 342
Special Tractor for Road Work 342
Huge Motor Truck Merger Under Way 342
Contractors Refuse to Bid 343
Bituminous Clay Pipe May Replace Cast Iron . . 343

MEETINGS:

Calendar 340
American Road Builders Elect Wasser President . 340
Road Officials Aid in Organizing American Construction Council 340
PERSONAL MENTION 344

*Illustrated Article

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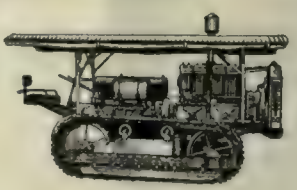

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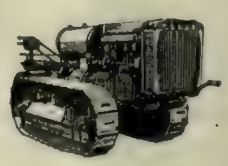

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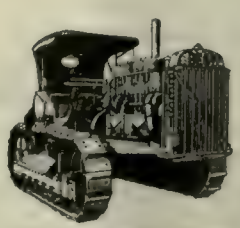

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Vol. LXII. NEW YORK, N. Y., JUNE 21, 1922 No. 25

The Bates Experimental Road Tests

The Third of the Traffic Runs Conducted by the Illinois Division of Highways is Completed and Results Announced

The third of the traffic runs to be conducted on the Bates experimental road by the Illinois Division of Highways was completed June 3 when the last of 3,000 applications of the load was applied to the pavements. The details of the first run appeared in the issue of April 26 and of the second in the issue of May 31. The load used in the third run was 4,500 lb. on each of the rear wheels of the truck and 2,000 lb. on each of the front wheels. The same trucks were used in this case as in the previous runs. The increased weight was obtained by piling brick in the rear of the bodies. The load was applied to correspond to 450 lb. per in. of nominal width of rear tire and 400 lb. per in. of width of front tire.

As in the second run, both day and night traffic was imposed upon the pavements. Exactly 2,000 applications of the load were given the sections in the daytime and 1,000 applications were made at night at the time when the most extreme curling action is present. The track of the traffic was exactly the same as in the last of the previous run, the trucks traveling with the outside edge of the rear wheel 2 ft. 6 in. from the north side of the pavement and at the extreme edge on the south side. At the completion of the day applications, it was noticed that the first five sections, constructed of bituminous filled brick on macadam bases of various thicknesses, were broken up to such an extent that it was practically impossible for the trucks to travel at their assigned speed of 12 mi. per hour. For this reason a turn-around was constructed at section 5 and no further traffic was imposed on the first five sections. These sections will be left in the present condition until the tests are completed in order that visitors can view the conditions brought about.

Between 14 and 16 trucks have been used under the last increment of load and the number of applications made during the day and night has increased considerably over that obtained in previous runs. There were as many as 400 applications made during the day runs and 350 applications at night during the last tests.

Third Load in Terms of Tensile Fibre Strength

A load of 4,500 lb. applied 6 in. from the corners of a 4-in. rigid pavement produces a tensile fibre strength of up to 650 lb. or approximately 100% of the strength of the concrete if the corners are considered as unsup-

CORNER FAILURES ON 4-IN. CONCRETE SECTION

COMPLETE FAILURE OF BRICK ON MACADAM BASE

ported cantilevers. Under this load it was natural then that all 4-in rigid pavements should show failures.

This load applied in like manner to a 5-in. rigid pavement produces a tensile fibre strength of up to 400 lb. or approximately 65% of the strength of the concrete. As this stress is above what has been indicated as the critical percentage to produce fatigue in concrete, it was expected that failures might be produced through fatigue under this load.

A tensile fibre strength of up to 300 lb. results in the concrete of 6-in. rigid pavements under this load, if applied in the manner stated above.

Corner Failures Under 4,500 lb. Load

Under the last increment of load, 26 decisive corner failures resulted. Of this number 12 occurred during the day runs and 14 at night. Three corner failures developed on the north side of the pavement and 23 on the south side. Only one failure occurred at night on the north side of the pavement.

More Failures at Night

It is to be noted that more failures occurred at night under 1,000 applications of load than occurred during the day runs with 2,000 applications. This in itself is indicative to a conclusive degree that the curling action of the pavements makes these slabs more susceptible to failure at night than at any other time.

Plans for a Fourth Traffic Run

The next increment of load to be applied will be such that each rear wheel of the trucks will carry 5,500 lb. and each of the front wheels, 1,900 lb. It is probable that 3,000 applications of this load will be made before the next increment is applied. Present plans call for the running of 1,000 applications in the daytime, 1,000 at night, and a final 1,000 in the daytime again.

Summary of Results of Tests

Sections 1 to 5, inclusive, bituminous filled brick on a macadam base, were noted as continuous and complete failures under the second increment.

The next six sections are asphaltic concrete on a macadam base. Section 6, 2-in. Topeka mix top course on a 10-in. macadam base, is considered to have reached its maximum carrying capacity under the 4,500 lb. load. Section 7, 2-in. Topeka top on an 8-in macadam base, is not considered equal to this third increment of load. No failures were reported on Section 8, 1.5-in Topeka and 1.5-in. binder two course top on a 5-in. base, on the first two traffic runs but two points of incipient failure appeared on the third. Section 9, 2-in. Topeka on a 6-in. base, showed six points of incipient failure under the second increment and two additional points under the third. Section 10, 2-in Topeka top on a 4-in. Novaculite base, was a continuous and complete failure under the first increment and Section 11, 2-in. Topeka top on a 4-in. macadam base, failed completely under the third increment.

No additional failures appeared on the 12 asphaltic concrete on Portland cement concrete base sections with the exception of sections 13 and 14. This indicates that corner and curb cracks noted under the second increment were not decisive failures. Section 13, 1.5 in. top on a 4-in base, showed one additional crack in curb and base not in the vicinity of any joint or crack. The previously reported curb cracks apparently were not serious. Section 14, 2-in. top on a 4-in. base, showed one additional crack in curb and base not in the vicinity of a transverse crack or joint. The previously reported curb crack and corner break were apparently not of a serious nature.

The behavior of the 14 sections constructed of lug and lugless brick with bituminous filler on a Portland cement base varied greatly. The first four sections, 3-in. lug or lugless brick on 6.5 and 5.5 in. base, have shown no apparent failures to date. Sections 26A, 4-in. lug brick on a 4-in. base; 29A, 3-in. lug brick on a 4.5-in base; 30, 3-in. lug brick on a 3.5-in. base; 1-2-3½ mix; and 32A, 3-in. lug brick on a 3.5-in. base 1-3-5 mix, appear to have reached their limit under the second increment. Section 26B, 4-in. lugless brick on 4-in. base, showed one additional crack in curb and base not in the vicinity of a transverse crack or joint. Section 27, 3-in. lug brick on 4.5-in. base had no additional failures but a previously reported corner break was found to be decisive. The next differed from section 27 only in the use of lugless brick. One decisive corner break was noted. Section 29B, similar to 29A except for the use of lugless brick, showed no additional failure. Sections 31 and 32B, the lugless brick duplications of 30 and 32A showed no additional failures and the behavior of the latter seemed to indicate that it had not yet reached its maximum capacity.

Sections 33 to 39, inclusive, are brick, constructed monolithic or semi-monolithic, on a Portland cement concrete base. The first section was reported as a complete failure under the first increment. Additional destruction to sections 34A and 35 under the third increment leaves no doubt but that these sections failed decisively under the second increment. The load carrying capacity of section 36 has been exceeded by the 4,500 lb. load. Section 37 has approached its limit although it can not be said to have failed decisively. It is not until we come to the combinations of 4-in. brick on 3-in base and 4-in. brick on 4-in. base that we find this type of road standing up to the traffic. The first type shows one decisive corner failure and one interior break while the other shows four breaks in the brick surface not considered decisive.

The remaining 26 sections are Portland cement concrete varying in thickness from 4 to 9 in. The sections from 40 to 54, inclusive, which vary from 9 to 5 in. with crushed limestone as coarse aggregate show no apparent failure to date. The behavior of section 55, 5-in. concrete using gravel as coarse aggregate, indicates that the carrying capacity was reached under the second increment. Section 56A, 5-in. concrete, crushed limestone aggregate with 4% calcium chloride in the mix, failed decisively under the third increment. The

remaining 75 ft. of section 56 using 2½% calcium chloride showed several new cracks in the section apparently not decisive. Section 57, 5-in. in thickness using Cemite cement, failed decisively under the present load, as did section 59 which is 4-in. thick using the same kind of cement. Sections 60 to 62, inclusive, all 4-in. in thickness with various special features, have failed under this increment of load. Section 58, 4-in. concrete on a 4-in. rolled stone base course, showed one corner failure in addition to a previously broken corner but the failures are not considered decisive. The last two sections, 7-in. in thickness show no apparent failures.

The Effect of Initial Pavement Design Upon Ultimate Cost*

Economic Considerations Evolved in the Construction of Concrete Highways With and Without an Asphalt Surface-Determination of the Relative Expense

By WALTER E. ROSENGARTEN†

Because of the keen competition among the various types of pavement, we are apt to lose sight of their inter-relationship and to regard them as distinct and independent types. A moment's reflection makes clear the fallacy of such an impression. Brick pavements are now laid with asphalt filler and there are developments along lines of asphaltic base and cushion so that this type of pavement is now about as distinctly an asphalt pavement as are asphalt macadam, asphaltic concrete and sheet asphalt. The same holds true in the case of granite block. Portland cement concrete, it is true, starts with only the bituminous joints but it uses a bituminous filler for cracks and there are few engineers who oppose the soundness of the practice of ultimately surfacing the concrete with an asphaltic top. As a matter of fact, few engineers disagree with the practice of resurfacing any type of pavement constituting a stable foundation with a wearing surface of asphalt. There is really, then, no actual antagonism between asphalt and the other types of pavement. This I wish to make clear so what I have to say here may stand as an economic presentation free from commercial bias.

Regarding asphalt, therefore, as an important factor in each type of pavement rather than as a type distinct and apart, it is pertinent to study the economics of its relationship to other materials and to types without giving any great weight to the question of competition.

Just now, in view of the more general use of the plain and reinforced Portland cement concrete and the asphalt surfaced highways on country roads, much prominence is being given to the question as to whether it is more economical to construct a Portland cement concrete pavement and delay placing the asphalt wearing surface until deterioration of the pavement renders it necessary, or to construct the complete pavement of concrete base and asphalt top at the outset. Maryland has followed the former course and has obtained an average of from 5 to 7 years use of the concrete before placing an asphalt top on the old pavement.

Laying aside for the moment all consideration save that of ultimate cost over a period of years, say 40, it cannot fail to be helpful to weigh the economic results of the two methods.

Certain factors must enter into such a consideration. These are (a) first cost of the concrete base, the asphalt top and the complete Portland cement concrete pavement; (b) interest rate; (c) life in years of the base, the top and of the concrete pavement before resurfacing.

In any specific case, we have the actual first cost values, thus the assumptions open to controversy are only those of the life of the respective portions of the pavement under (c). Even there we have much reliable evidence as to the average age of asphalt pavements. The 1921 report of the Engineer Department of the District of Columbia says in connection with its asphalt pavements, "that some of the streets approximate an age of 40 years and that the average age of those we have resurfaced in recent past years exceed 25 years." The Department of Public Works of Manhattan Borough, New York City, has advised us that they find the average age of their asphalt pavements to the time of resurfacing to be 18.2 years including the most heavily traveled streets open to truck traffic. The annual report of the Bureau of Engineering of the City of Buffalo for 1919 gives the average age of asphalt pavements replaced in the four years previous at 24.47 years. We have been advised by the chairman of the Paving Commission of Baltimore that the average age of asphalt pavements in that city is in excess of 25 years.

In this paper I have, however, assumed a life of only 20 years for the asphalt top, preferring to lean to the side of conservatism. For the concrete base, whether it be laid at the outset as a base or used as a wearing surface and later as a base, I have estimated 40 years. This may be too liberal in view of the possible unsuit-

*Paper presented at the State Conference of Mayors and City Officials, Poughkeepsie, N. Y., June 7, 1922.

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ability of the concrete pavement as a base after deterioration. This leaves for determination the period of time which may be allowed for the concrete pavement laid as such before an asphalt top becomes necessary in order to prevent economic loss. As I have already stated, Maryland has found this period to lie within about 7 years. California has found it to be even less. True these states have laid pavements of leaner mix and lesser thickness than other states, but if we seek to glean facts from service history, we must turn to those pavements which have been down long enough to yield such facts. According to the best available figures, I find that 95% of all the Portland cement concrete roads in this country today are less than 7 years of age and their average age probably not more than 3 years. Let us assume that within reasonable cost limits the concrete pavement will go 7½ years' average before an asphalt top is required.

Let us now see from an actual cost analysis how this works out. As a basis for comparison it may be considered that the original outlay for any part of the construction will be paid off by equal annual amounts extending over the life of the improvement. This annual cost can be found readily by consulting standard annuity tables, as given in Figure 1, for the appropriate rate of interest and the life of that portion of the pavement under consideration. By this annuity method, we have a very simple means of determining the relative annual and also the total costs for various types of construction. Let us take as a specific case, a concrete road 7 in. thick, 1:2:4 mix, which costs $2.50 per sq. yd. After 7½ years, it is surfaced with 2 in. of asphaltic concrete costing $1.30 per sq. yd. Compare this with 5 in. of Portland cement concrete base, 1:3:6 mix, surfaced at the outset with 2 in. of asphaltic concrete at a total cost of $2.80 per sq. yd. The life of the Portland cement concrete regarded as a base is placed at 40 years and the asphalt wearing surface at 20 years.

TABLE 1.
ANNUAL COST REQUIRED TO RETIRE A $1.00 INVESTMENT WITH INTEREST AT VARIOUS RATES

Years	4%	5%	6%
1	1.04000	1.05000	1.06000
2	0.53019	0.53780	0.54543
3	0.36034	0.36720	0.37410
4	0.27549	0.28201	0.28859
5	0.22462	0.23097	0.23739
6	0.19076	0.19701	0.20336
7	0.16660	0.17281	0.17913
8	0.14852	0.15472	0.16103
9	0.13449	0.14069	0.14702
10	0.12329	0.12950	0.13586
12	0.10655	0.11282	0.11927
15	0.08994	0.09634	0.10296
20	0.07358	0.08024	0.08718
25	0.06401	0.07095	0.07822
30	0.05783	0.06505	0.07264
35	0.05357	0.06107	0.06897
40	0.05052	0.05827	0.06646

The annual cost as well as the total cost of the various portions of the pavements included in this discussion are obtained from the annuity table in Fig. 1 in the following manner. Take for example the Portland cement concrete pavement costing $2.50 per sq. yd. used first as a pavement and later as a base for a combined period of 40 years and, if we assume an interest rate of 5% on the investment, we find from the annuity table that an expenditure of $1.00 can be paid off over a 40-year period by annual payments of $.0583. An expenditure of $2.50 would therefore require annual payments of 2.5 times $.0583 or $.1457. This would make a total in 40 years of $5.8278 per sq. yd. Similar costs for the other portions of the pavements are as follows:

Type	First cost	Interest rate	Life yrs.	Annual cost per. sq. yd.	Total cost per. sq. yd Yrs.	Amt.
A	$2.50	8%	40	$0.1457	40	$5.8278
B	$1.30	5%	20	$0.1043	32½	$3.3897
					40	$4.1720
C	$1.50	5%	40	$0.0874	40	$3.4967

Type A—Portland cement concrete pavement used as a base after 7½ years.
B—Asphaltic surface.
C—Portland cement concrete base.

Taking a period of 40 years for comparing these two methods of construction, since this is the estimated life of the base, we find the total cost of the Portland cement concrete pavement surfaced after 7½ years with asphalt, to be $5.8278 plus $0.1043 times 32½ years or $9.2175, while on the other hand the total cost of Portland cement concrete base surfaced originally with asphalt is $3.4967 plus $0.1043 times 40 years or $7.6687.

From this we see that there is a saving by constructing the road originally with an asphalt surface on a concrete base of $1.5488 per sq. yd. Thus the cost is 20.2% greater when the placing of an asphalt surface is delayed than when it is made part of the initial construction.

Now to give you the benefit of variations in the factors, let us first show a variation in design. The first charts show a 7-in 1:2:4 Portland cement concrete pavement costing $2.50 per sq. yd. resurfaced after 7½ years with a 2 in. asphaltic course costing $1.30 per sq. yd. compared with a 5-in. 1:3:6 concrete base surfaced with 2 in. of asphalt costing $2.80 per sq. yd.

Let us compare an 8-in. 1:1½:3 Portland cement concrete pavement costing $3.00 per sq. yd. surfaced after 10 years with 3 in. of sheet asphalt costing $1.50 per sq. yd. with a 6-in. 1:3:6 concrete base surfaced with 3 in. of sheet asphalt costing $3.00 per sq. yd. The annual and total costs under these conditions are as follows:

Type	First cost	Interest rate	Life yrs.	Annual cost per. sq. yd.	Total cost per. sq. yd. Yrs.	Amt.
A	$3.00	5%	40	$0.1748	40	$6.992
B	$1.50	5%	40	$0.0874	40	$3.496
C	$1.50	5%	20	$0.1204	30	$3.612
					40	$4.816

Type A—8 in. 1:1½:3 P. C. C. pavement.
B—6 in. 1:3:6 P. C. C. base.
C—3 in. sheet asphalt surface.

Thus we have for the total costs Portland cement concrete pavement $6.992 plus an asphalt surface for 30 years costing $3.612 or a total of $10.604, as compared with the Portland cement concrete base $3.496

plus an asphalt surface for 40 years, $4.816 or $8.312 differential of $2.292 or 27½% in favor of the pavement surfaced with asphalt at the outset.

Next let us see what a variation in costs will yield.

You may have a problem with different first costs from those assumed. Turning back to the first problem and assuming as before the life of the Portland cement concrete as a base to be 40 years, the life of the asphalt surface as 20 years and the time for surfacing the Portland cement concrete pavement as 7½ years, we have by reference to the annuity table the following relation:

Let C = the first cost per sq. yd. of the Portland cement concrete pavement.
K = the first cost per sq. yd. of the Portland cement concrete base.
A = the first cost per sq. yd. of the asphalt surface.
Pp = the annual payment for a first cost of $1.00 obtained from the annuity table for the appropriate period, p.

Total cost P. C. C. pave. surf. after 10 yrs.
$=P40\times40\times C+P20\times32\frac{1}{2}XA$
$=2.332C+2.607A.\ .\ .\ .\ .(1)$

Total cost P. C. C. base asphalt surface
$=P40\times40\times K+P20\times40XA$
$=2.332K+3.208A.\ .\ .\ .\ .(2)$

Let us make a variation of 20 ct. each way from the first costs assumed of $1.50 for the concrete base and $1.30 for the asphalt surface. Substitute in the above formula, we have:

When C = $2.50; K = $1.70; A = $1.10
(1)....2.332×$2.50+2.607×1.10 = $8.698
(2)....2.332×$1.70+3.208×1.10 = $7.493

showing a total increase of $1.205 or 16% when the asphalt surface is delayed.

When C = $2.50; K = $1.30; A = $1.50
(1)...2.332×$2.50+2.607×$1.50 = $9.740
(2)...2.332×$1.30+3.208×$1.50 = $7.843

showing a total increase of $1.897 or 24% when the asphalt surface is delayed.

To view this from still another angle, let us find how much we are justified in paying for the Portland cement concrete pavement over and above the cost of a Portland cement concrete base if the pavement will give service unprotected for 7½ years. The difference in total cost in the first problem was $1.5488. This represents an initial payment 40 years previously of $.665 obtained by dividing the $1.5488 by 2.3311. The last figure is arrived at by taking the appropriate figure in the annuity table which is then multiplied by 40 to get the aggregate cost of a $1.00 investment over a 40 year period. This indicates that the initial cost of the Portland cement concrete pavement of $2.50 must be reduced by $.66 giving $1.84. We therefore find that we can pay but 34 ct. per sq. yd. more for a first class Portland cement concrete pavement than for a Portland cement concrete base to be used under an asphalt surface, or a difference of no more than one-third than now prevailing in actual construction practice.

Let me again emphasize my opening statement that the whole purpose of this paper is to analyze cost of the two methods from a strictly economic standpoint. There are many factors such as ease of traction, appearance, noiselessness, etc., which the engineer will consider other than that of cost and each of them would serve as a subject in itself for a paper but I feel that in the interest of clear thinking and sound practice this one very important consideration should be studied exhaustively on its own merits. One factor which might seem to have a place in this discussion is that of maintenance but that it is not material to the discussion I can easily show you. As the Portland cement concrete in the examples cited is covered with asphalt 32½ years of the 40 years or in any event over the major portion of the period the difference in maintenance cost would be only for the portion during which the concrete was serving as a pavement and this difference would be spread over the entire 40 years. You can see therefore that the difference in maintenance costs between the two methods would be at most no more than a fraction of a cent per yd. either way and would not materially affect the totals.

Finally, I am only stating a truism when I say that unless a proposition is fundamentally sound it must ultimately fail. We merely deceive ourselves when we try to believe that which we want to believe regardless of its fundamental soundness. I am therefore earnestly putting this before you as an economic question and asking you to subject it to every test as a condition to accepting it as a guide.

CALIFORNIA OBTAINS CONVICTIONS FOR OVERLOADING

Trucks using the state and county highways of California are limited to a gross load of 30,000 lb. From March 1 to May 1 the inspectors of the state highway commission inspected 277 trucks and found 27 violating this limit. On the basis of weight per in. of tire, 111 or 40% were found to be overloaded and 35 or 12 2-3% were using too thin tires. Fifty-one convictions were obtained and 104 overloads were adjusted or removed.

VIRGINIA TO TRY FORCE

Danger signs, warning bells and wide-spread educational campaigns have all failed to make motorists careful at grade crossings and Virginia under a recent enactment proposes to see if recklessness can be stopped by law. The new law provides that the drivers of all vehicles, on approaching a grade crossing outside of the corporate limits of any town, must come to a full stop "not less than 10 ft. or more than 100 ft. from the nearest rail." The penalty is a fine of $10.

GROUND BROKEN FOR NEW TUNNEL

While the Jersey City Chamber of Commerce was planning a celebration for the breaking of ground for the New York and New Jersey vehicular tunnel, engineers representing the New York and New Jersey Bridge and Tunnel Commission, the Erie Railroad, and Booth & Flinn, L'td. went quietly to the Erie yards in Jersey City on May 31 and opened the ground for the project. Clifford M. Holland, Chief Engineer of the tunnel commission, turned over the first shovelful of earth.

THREE YEAR FEDERAL AID PROGRAM FOR ROAD CONSTRUCTION

In accordance with the provisions of a bill just signed by the President, federal aid for road construction will be continued throughout the three fiscal years ending June 30, 1925, approximately fifty millions of dollars having been authorized for the work during the coming twelve months, with $65,000,000 and $75,000,000 respectively appropriated for each of the two succeeding fiscal years. In addition, $6,500,000 is authorized for forest roads for each of the two fiscal years beginning July 1, 1923, and July 1, 1924. The funds will be administered by the Secretary of Agriculture through the Bureau of Public Roads.

The approximate apportionment for each of the various states is as follows:

Alabama	$1,035,614
Arizona	702,188
Arkansas	836,095
California	1,641,399
Colorado	894,117
Connecticut	320,599
Delaware	243,750
Florida	591,217
Georgia	1,331,972
Idaho	625,691
Illinois	2,164,187
Indiana	1,305,406
Iowa	1,401,915
Kansas	1,401,521
Kentucky	944,786
Louisiana	664,660
Maine	463,440
Maryland	427,086
Massachusetts	730,784
Michigan	1,499,688
Minnesota	1,415,731
Mississippi	863,271
Missouri	1,632,086
Montana	1,031,257
Nebraska	1,054,126
Nevada	635,624
New Hampshire	243,750
New Jersey	628,581
New Mexico	793,216
New York	2,464,299
North Carolina	1,139,556
North Dakota	776,476
Ohio	1,882,003
Oklahoma	1,168,226
Oregon	788,443
Pennsylvania	2,265,969
Rhode Island	243,750
South Carolina	707,492
South Dakota	802,707
Tennessee	1,098,461
Texas	2,950,115
Utah	561,278
Vermont	243,750
Virginia	971,219
Washington	735,806
West Virginia	534,906
Wisconsin	1,263,211
Wyoming	623,078
Total	$48,750,000

These funds must be matched by the states and will be administered subject to the general provisions already in force.

The new legislation reduces the maximum participation on the part of the government from $20,000 to $16,250 per mi. for roads constructed with the appropriation for the next fiscal year, and $15,000 per mi. thereafter. Bridges over 20 ft. in span may be considered as separate projects to which this limitation does not apply. In states where more than 5 per cent of the area is unappropriated public land, provision is made for an increase in the amount per mi. The act also provides for the extension of federal aid to the construction of structures required for the elimination of railroad grade crossings.

Important provisions of previous acts under which large funds have been successfully administered are applicable to the new funds. States must maintain adequate highway departments. Funds to match federal aid must be placed under the direct control of the state highway department. The type of surface constructed must be adequate for the traffic anticipated. with reasonable grades, curves, and other features. States must obligate themselves to maintain all federal-aid roads constructed, and in case this is not done any federal funds available for new projects may be withheld until they are put into satisfactory condition. All federal-aid funds must be spent on a connected system of roads consisting of not more than 7 per cent of the total mileage in each state and divided into primary or interstate roads and secondary or inter-county roads.

Plans for the proposed system have been received by the Bureau of Public Roads from all but eight states, and the state systems are being co-ordinated so that when joined together they will serve the best interests of the whole country. In the meantime only projects certain to be on the proposed system are being approved.

LOWER PRICES FOR VARIOUS HIGHWAY MATERIALS REPORTED

A considerably lower level of prices for the various items entering into highway construction is reported by the U. S. Bureau of Public Roads. This conclusion is based on the following prices by successful bidders on federal-aid roads during April and are averaged for the whole of the United States. Some of the figures cover a large volume of work well distributed over the country, while others are based either on small volumes or scattering reports.

The figures which cover the cost in place are as follows: earth excavation, common, 33 ct. a cu. yd.; rock excavation, $1.26 a cu. yd.; gravel, $1.44 a cu. yd.; sand-clay, 45 ct. a cu. yd.; crushed stone, $3.42 a cu. yd.; structural concrete of various classes range from $14 to $21.20 a cu. yd. For surfacing the following are the prices by the sq. yd.: gravel, 40 ct.; surface-treated macadam, 50 ct.; bituminous macadam, $1.06; bituminous concrete, $1.97; plain cement concrete, $2.17; reinforced cement concrete, $2.54; and brick, $3.70. Reinforcing steel has cost $0.053 a lb. and structural steel $0.059 a lb. Cement has been furnished to contractors by the following states at the prices given by the barrel: New York, $1.73; Wisconsin, $1.94; and Arkansas, $2.70.

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

Founded January, 1892

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Editor

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Copy for advertisements must reach the New York office by noon on Tuesday of the week before date of issue if proofs are to be submitted.

Copy for classified and other advertisements where proofs are not required will be accepted until noon on Monday of the week of issue.

Articles by road builders are solicited. They should be short and, if possible, accompanied by photographs. Those accepted will be paid for at current rates.

Vol. LXII. June 21, 1922 Number 25

A STORY WITH A MORAL

Several years ago, a certain highway engineer was sent out to take charge of a $1,000,000 state road construction job. As the work would stretch over an indefinite period, he chose to make his home in a small city near the work. In his hunt for temporary lodgings, he was asked by one landlady what his business was. When he replied that he was an engineer, he was confronted with the question as to whether he worked for the New York Central Railroad or the West Shore. His explanation that he was to work on the new road probably left the impression that he was to run a steam shovel or a locomotive crane, but he considered the question rather amusing and did not think it worth while to explain to the lady the difference between a civil engineer and a locomotive engineer in such a way as to impress her with his importance.

The engineer in charge of this contract made his home in or near that city for seven or eight years and completed the job which was one of the great engineering feats of its kind in the world, but nobody ever found out about him. The people who were interested enough to watch the progress of the work did not know the name of the chief engineer and the people who knew him personally had no very clear conception of what he really did on the work. The Kiwanis and Rotary Clubs became interested in the project and wanted to hear about it. By that time, the contractor had become known to the business men of the city and they invited him to speak to them. The engineer was better fitted in every way to give them the facts they wanted.

Finally, the work neared completion and plans were formed for an opening celebration. At a meeting to discuss these plans with the local committees, the state highway commissioner referred to the man who had put the road through as, "an employee of the department who has been in touch with the work from the start." No mention of the engineer's name was made and he was not present at the meeting. By the time the celebration is held, he will probably have been transferred to a new job and will not be able to be present at that either. Meanwhile, the commissioner and all the other politicians in the state, who by any stretch of the imagination can scrape up a connection with the building of the road, will get all the publicity.

There is a moral in this tale for engineers and it is not very hard to find. Don't work so hard that you have no time to take part in the civic life about you. Don't let yourself be pushed into the background of the picture. Remember that the taxpayer is your employer and try to impress him with your importance. Take a lesson from the politician. Get all the publicity you can. The engineer of the story had a great responsibility and he was sadly underpaid. Why?

ROAD TESTS IN ILLINOIS

The tests of the Bates experimental road, the results of which are summarized elsewhere in this issue, are carried on by the Illinois Division of Highways with the cooperation of the U. S. Bureau of Public Roads. Valuable as the results of these tests will be to road designers and builders all over the world, the difference in soil and climatic conditions in various localities make it necessary for other similar tests to be conducted under different conditions. The action of the Illinois Division of Highways in carrying out these tests should be an example for the other state highway departments to follow. The Bureau of Public Roads recognizes the importance of research and experimentation and its cooperation is assured. Not that the destruction of test roads should be attempted by the other states on the scale of the Illinois tests, but each highway department should have a research division to carry on field and laboratory experiments. Through the cooperation of the federal bureau, or some other central agency, the work could be mapped out to prevent duplication and the results collected and put into the most advantageous form. There is need for some such country-wide research organization and the matter merits the attention of the executives at the heads of the state highway departments.

The U. S. Civil Service Commission has announced a competitive examination for highway bridge engineer in the Bureau of Public Roads at a salary of $1,800 to $2,100 a year. Applications must be filed with the commission before the closing of business on June 27.

MEETINGS

Calendar of Coming Meetings

June 21-22—American Society of Civil Engineers—Annual convention, Portsmouth, N. H.

June 26-July 1—American Society for Testing Materials—Twenty-fifth annual meeting, Atlantic City, N. J. Secretary, C. L. Warwick, Engineers' Club Bldg., Philadelphia, Pa.

Aug. 9-10—Custer Battlefield Highway Association—Annual meeting, Sheridan, Wyo. Secretary, W. D. Fisher, Sheridan, Wyo.

Oct. 2-6—American Society for Municipal Improvements—Annual convention, Cleveland, O. Secretary, Charles Carroll Brown, St. Petersburg, Fla.

AMERICAN ROAD BUILDERS ELECT WASSER PRESIDENT

The deadlock, which resulted from a tie vote for the office of president of the American Road Builders Association at the annual meeting, May 15, was broken at an adjourned session of that meeting held in New York June 15, when the board of directors retired during a recess and elected Thomas J. Wasser, State Highway Engineer of New Jersey, to the office.

The adjourned meeting opened with about fifty members present and, on recommendation of the directorate, voted to declare illegal the election of the seven members of the board of directors, whose election was announced May 15, on the ground that the nominating committee had not notified the secretary of its choice 60 days before the annual meeting and further that the secretary had failed to mail out the letter ballots 30 days before the election was to take place, as provided for in the constitution and by-laws. After such action the seven members whose terms expire in 1922 were restored to membership on the board until such time as their successors can be legally elected, and were qualified to vote for president.

An announcement was made that the board of directors, in a meeting subsequent to the meeting of may 15, had adopted an amendment to the constitution which provided for a meeting of the board to hold an election for any office in which a vacancy might occur. Under the provisions of this amendment the board retired during a recess of the meeting and, after an hour's deliberation, returned to announce the result of the balloting. Of the 27 votes cast, 15 were received by Mr. Wasser and 12 went to other candidates.

While the tie vote of May 15 indicated a rivalry between two factions of the organization and the discussions at the recent meeting were acrimonious and spirited, the election of Mr. Wasser was the signal for the burying of the hatchet. The new president took the chair and spoke briefly to state his policies for the year and his hope for unity and cooperation. Various members spoke from the floor and assured the president and the meeting that all past grievances were already forgotten and that all would work together for a bigger and better organization. The meeting adjourned in a spirit of complete harmony and accord.

ROAD OFFICIALS AID IN ORGANIZING AMERICAN CONSTRUCTION COUNCIL

Among the prominent speakers at the organization meeting of the American Construction Council held in the Hotel Washington, Washington, D. C., attended by two hundred representatives of the ten major groups of industries which compose the whole construction industry, was Thomas H. MacDonald, Chief of the Bureau of Public Roads, who emphasized the relationship of highway building to the whole construction industry. He said:

"The Bureau of Public Roads and officials of state highway departments must study first, last and all the time the interests of the public.

"The entire highway program of the United States is under the administrative control of public officers. Therefore these men are not at liberty always to act as they would if they were occupying a private position, but are actuated and governed by the laws which have been established by the public to guide and control their actions.

The passage of the federal aid highway acts stimulated roadbuilding in the United States so that it has grown into what we may call a major industry. But the very big nature, the very fundamental of the federal aid highway acts has been the cooperation expected through them between the federal government and the states. Since 1916 the states and the federal government have been working out their problems of cooperation, and I believe they have their major problems pretty well settled. That leaves that industry organized in such a way that it can cooperate with any major construction council that may be set up to solve the large construction problems in the interest of the public.

"The highway commission is willing to cooperate, and is organized to fill any opening and to fall into step without practicing marching order very much."

An address which emphasized the importance of coordination was made by Frederick L. Cranford, of New York, vice-president of the Associated General Contractors of America. He said:

"For forty years American business has been passing through a transformation from individualistic to

collective and cooperative activity, but the cooperation so far developed in construction has proved ineffective. Our exerience of the last few years indicates clearly the road, which is the cooperation of all the elements of construction, because collectively our interests are and must be unselfish.

"There can be no more difficult industry to coordinate and none with a larger number of its members pure individualists, but the coordination of no other industry is so important to the well being and prosperity of our people, for we are the agents through whom the nation's natural, material, economic and artistic resources are built and developed."

The meeting was opened by Secretary of Commerce Hoover, who declared that "if we would stem the tide tending to refer every little need and complaint to the government, action to meet these demands must arise from within industry itself."

A warning against "an intense stratification of the various economic interests in our national life" which leads to selfish aims and purposes was sounded by Willis H. Booth, vice-president of the Guaranty Trust Company of New York, who followed Secretary Hoover.

Franklin D. Roosevelt, formerly Assistant Secretary of the Navy, was elected president of the council at the close of the two-days' session.

MOTOR BUSSES ON HIGHWAYS AND THEIR RELATION TO RAIL LINES

Motor trucks, motor busses and highways were discussed by Zenas W. Carter, of the White Motor Trucks Company, in an address made recently before the Central Electric Railway Association, aboard the steamer "South American," on the Great Lakes. The interest of the electric railways in the development of the motor truck and motor business on the public highways was emphasized, the topic being a specially timely one in view of the steadily increasing competition between the former and the latter.

The speaker pointed out that "the electric railway operator finds his attention more and more upon the problem of co-ordinating motor trucks and motor busses with his electrical operation." The question of the economy of motor trucks and motor busses when used by electric railway companies, he said, "has too many factors for anyone to offer more than a statement of some of the operations already under way. For instance, six months ago an officer of one of the Ohio electric railway companies made the statement that they were not interested in motor busses. At the present time this company has determined that it will be economical for them to purchase, and their order has been placed for five special motor busses. These are to be operated on highways paralleling their present lines."

Further evidence of the manner in which the highway has entered into competition with the railway in the matter of transportation is found in the statement that "if they had not initiated bus operation covering the territory, someone else would have started this service. Their franchise was in jeopardy because the public in the territory was not adequately served by the present electric service."

It was also noted by the speaker that "another company, the Northern Ohio Traction Company of Akron, found by careful study and survey that there was an opportunity to keep competition from their electric lines and at the same time operate busses at a profit by initiating two bus lines." He pointed to the "hundreds of motor bus lines in the United States in territory which was not being served by either electric or the steam companies," and concluded that "with almost eleven million motor vehicles already on our highways it will be just a short time until all individual highway transport will be by motor."

Of the future of the motor bus on the highways he said: "In the motorization of our highways, the motor truck has been ranking next to the passenger car in importance up to the present time, but it is very probable that the use of the motor bus will soon exceed even the use of the truck in the revolutionizing of our highway transport. The motorization of our highways is itself the economic force which has compelled the betterment of our highways. The improper use of highways by overloading motor vehicles should be denounced, and effective legislation enacted to curb this practice."

MINNESOTA HIGHWAY MAPS GAIN WIDE DISTRIBUTION

The Minnesota State Highway Commission is directed by law to publish a map of the state highway system for free distribution. Charles M. Babcock, State Highway Commissioner, adopted the plan of distribution through newspapers in the belief that the saving on postage would pay for more maps and thus a larger number of highway users would be served without additional expense to the state. Coupons are printed in papers throughout the state together with an announcement of the arrival of the maps and a map is given out in exchange for each coupon brought to the newspaper office.

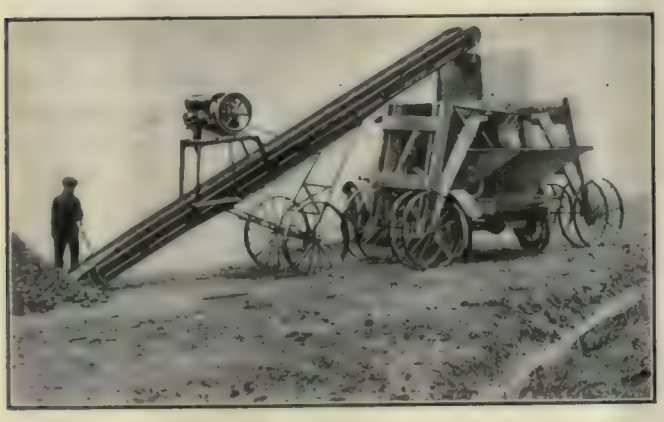
The maps are printed on good paper and show all the state trunk highways with the official numbers corresponding to those on the yellow star markers along the way. Bulletins issued monthly and printed in the newspapers supplement the maps by indicating progress of surfacing and other improvements. Many hotels, garages and business houses are placing the maps under glass for display purposes and fastening the condition bulletin each week in a space left for it.

Jefferson County, Alabama, is engaged in building 50 mi. of road at a total cost of $425,000. The money was raised by a bond issue.

Equipment—Trade—Materials

COMPLETE UNIT WILL HANDLE CONCRETE ROAD MATERIALS

A complete unit for handling the material on concrete road construction has been developed by the Portable Machinery Company of Passaic, N. J. The outfit consists of a contractor's type scoop conveyor, especially designed to handle abrasive material, a portable, adjustable measuring hopper, and an auto dump truck. It will handle all materials for the concrete mixer and will cut the usual man and wheelbarrow gang by ten or twelve men.



THE UNIT ASSEMBLED

A diagram in a folder just issued shows the stone piled at the left of the road and the sand and cement piled at the right. One conveyor and measuring hopper is assigned to each pile. The man in charge of the stone fills his hopper with the desired proportion of stone and the man at the sand pile does likewise with the sand and cement. The dump truck operator drives under the stone hopper and receives the charge of stone after which he drives to the other hopper and gets the sand and cement on top of the stone. The load is then driven to the mixer and discharged into the mixer hopper. By the time the driver has discharged his load and returned to the measuring hoppers, they are once more filled and ready with a new load.

The scoop conveyor is made in three sizes, varying according to length; 20, 25, and 30 ft. The width of trough is constant at 14 in. and the belt is the same width as the trough. Hard wood rollers are used under the belt because they damage it less than steel rollers. The conveyor is mounted on two roller-bearing wheels on a solid axle. The lifting and lowering device is both simple and safe. The machine is operated either by electric motor or gasoline engine mounted over the top.

A very attractive piece of advertising literature is a new catalogue of The Galion Iron Works & Mfg Co. which describes with illustrations their line of motor and steam road rollers.

HUGE MOTOR TRUCK MERGER UNDER WAY

The consolidation of the Selden Truck Corporation and the Atlas Truck Corporation into a new company known as the Industrial Motors Corporation marks the first step in a huge merger of truck manufacturing companies which the promoters hope to make as important in that field as the General Motors Corporation is in the passenger car field. Interests arranging the merger are negotiating with several other concerns including truck and parts makers in an effort to bring them into the group. Among those under consideration is the Martin-Parry Corporation, a maker of truck bodies, which is closely affiliated with the Atlas Truck Corporation.

SPECIAL TRACTOR FOR ROAD WORK

The tractor shown in the accompanying illustration is a Lauson 15-30 special road building tractor owned by Henry County, Georgia. It is continuously in use on the road of the county and is operated and taken care of by convicts from the state prison.

This model has been designed by The John Lauson Manufacturing Company of New Holstein, Wis., to meet every requirement of road building and maintenance. Extra heavy solid cast drive wheels, weighing 1,800 lbs. each, with 16-in. face and special steam engine type road cleats furnish the necessary traction for all kinds of road work. At the same time, the tractor is neat and compact and easy to handle. The Lauson-Beaver, 4¾-in bore, 6-in stroke, four cylinder, four cycle motor develops 15 h. p. when operating as a tractor and 30 h. p when operating as a stationary power plant with belt drive. There is an 18-in. drive pulley with 8-in. face running at a speed of 475 r. p. m. for belt work—driving crusher or gravel screening outfit. Equipment includes a Kingston carburetor, Dixie magneto, Taco governor, and Lauson transmission, selective sliding gear type, with two speeds forward

TRACTOR REPLACES MULES ON GEORGIA ROAD

and one reverse. Low and reverse speeds are 1¾ mi. per hour and high speed is 2½ mi. per hour. All working parts are completely covered and every gear is enclosed in a dust-proof housing.

The company also makes a smaller size Lauson 12-25 tractor for patrol work in which the same high grade and dust proof construction is carried out.

CONTRACTORS REFUSE TO BID

When the comissioners of sewerage of Louisville, Ky., asked for bids on May 23 for $1,000,000 worth of sewers to be constructed by the city, not a single bid was filed. The letting was readvertised for June 23 and, according to a statement issued by the Kentucky Association of Highway Contractors, Louisville contractors will again refuse to bid.

The difficulty between the commissioners and the contractors is the clause in the contract which makes the commission's engineer's decision final and conclusive on both parties to the contract.

"His estimate and decision," the contract reads, "shall be final and conclusive upon both parties to this contract."

The contractors refuse to become party to a contract in which an interested person is made the final judge in all disputes. They at first took the position that, as they were a party to the contract and the commission's engineer represented the other party alone, they were entitled to have all disputed points passed on by an arbitration board. Later they modified their request so as to provide that the orders and directions of the engineer should be executed without question, but that they should retain the right to have claims for compensation heard by jury.

In making this fight against what they consider unfair conditions, the Kentucky contractors feel that, if they are successful, they will have done a service for contractors and the public generally. Therefore, they are asking and expecting to receive the cooperation of contractors nationally.

BITUMINOUS CLAY PIPE MAY REPLACE CAST IRON

As a result of laboratory tests made at the College of Industries of Carnegie Institute of Technology at Pittsburgh, Pa., by S. E. Dibble, head of the heating and ventilating department, it has been established, according to an announcement from the institute, that bituminous clay pipe for drainage and sewerage use is in every way the equal of the more expensive cast iron pipe which has been used heretofore.

For years, says the announcement, efforts have been made by manufacturers and engineers to find methods of efficient substitution of bituminous clay pipe for cast iron pipe without success. One weak point has invariably remained; an inability to join the lengths to prevent leakage. Practically speaking, some variation of the ordinary building cement has been the one general type of jointing material used. Recently, various bituminous compounds have been evolved as a substitute jointing material but all the tests made of these, too, failed to overcome the great weakness of clay pipe when used for drainage or sewerage.

Finally, a number of these bituminous compounds were placed at the disposal of Professor Dibble and he proceeded to make a series of painstaking and unusual experiments and tests. He not only devised absolutely new equipment with which to simulate actual drainage and sewerage conditions in the making of his tests, but as a result of the tests, he developed an entirely new jointing practice and technique. Altogether 21 separate tests were made on a total of 63 joints and three different bituminous compounds were used.

Not only have Professor Dibble's tests established: (1) that a proper bituminous compound can be used efficiently in jointing a pipe; (2) that joints made in the manner developed by him will stand any pressure that the pipe itself is capable of standing, without showing any leak; (3) that a pipe line so jointed can be thrown out of alignment without causing a leakage at the joints; and (4) that leaks due to poor workmanship can be repaired easily and quickly; but has gone further and has published actual chemical analyses of two of the bituminous compounds found satisfactory.

WHEN CALLED ON TO SPEAK

The following hints for public speakers were suggested to students taking the Illinois short course in highway engineering:

1. Don't apologize for your presence as a speaker. If any apologies are made, let the management make them.

2. Don't tell the audience you are a poor speaker. If it is true, it will be found out soon enough.

3. Be brief. The orator who preceded Abraham Lincoln on the program at Gettysburg talked over two hours. Today we don't remember who he was or what he said. Lincoln spoke a few words and those immortal thoughts are a part of the life of every American. Draw your own conclusions.

4. Marshal your facts. The best extemporaneous speakers are those who have planned in advance what they intend to say and how best to say it.

5. Make every word hit the mark. If a word is not necessary, don't use it. You are not singing a swan song; you are presenting engineering facts.

6. Be heard! If you prepare the best information of the day, and then smother it by swallowing your voice, mumbling your words and slurring your syllables, your effort will be a rank failure. Every engineer can yell cross-section readings for 600 ft.; he can, therefore, make himself heard by a thousand people. Remember that if you are too quiet, the appointed coach in the rear will yell "louder."

7. Keep within your time limit. The other fellow may have a few valuable things to say also.

Personal Mention

THOMAS J. WASSER
PRESIDENT
AMERICAN ROAD BUILDERS ASSOCIATION

Thomas J. Wasser was born in Philadelphia, Pa., January 24, 1871. He attended the Philadelphia Manual Training School and also took a private course in engineering and is a civil engineer by profession. His experience in highway construction dates back to the nineties when he entered the employ of B. M. and J. F. Shanley Company of Newark, a concern which was engaged in macadam and telford road construction. Later he became associated with the Sanford and Stillman Company, general contractors and bridge builders. From 1903 to 1913 he was with the engineering bureau of the Robert W. Hunt Company and was engaged on county engineering assignments in Hudson County, New Jersey. During this period Mr. Wasser was the engineer in charge of the Fourteenth Street Viaduct in Hoboken and, jointly with James Owen, was engineer in charge of the reconstruction of the Lincoln Highway between Essex and Hudson Counties. In 1913 he became county engineer of Hudson County and in that capacity designed and supervised most of the construction of the Newark Turnpike which has been recently completed under his successor. In July, 1920, he resigned as county engineer to accept the appointment from the reorganized state highway commission to be state highway engineer in charge of the state's road construction program.

Mr. Wasser is also president of the State Board of Professional Engineers and Land Surveyors of New Jersey and is a member of the following organizations: American Society of Municipal Improvements, National Highway Traffic Association, American Associaton of Engineers, American Association of State Highway Officials, and associate member of the American Society of Civil Engineers.

G. H. Stanchfield has been appointed city engineer of Fond du Lac, Wis., to succeed R. B. Petters, resigned.

William J. Knauer, County Engineer of Chautauqua County, New York, has resigned to enter the contracting business.

Melnott N. Beebe, Street Engineer of Indianapolis, has been appointed senior assistant city engineer to succeed Henry P. Campbell, resigned to enter a private engineering firm. William Lacey, an assistant engineer in the department of public works, was promoted to the position of street engineer.

C. M. Hathaway, District Engineer of the Illinois Division of Highways, has been appointed engineer of construction to succeed B. H. Piepmeier who resigned to become state highway engineer of Missouri.

H. G. Dimsdale has been appointed highway commissioner of the Province of Alberta, Can.

OBITUARY

JOHN A. BENSEL

John A. Bensel, consulting engineer of New York City and former State Engineer of New York, died at his home in Bernardsville, N. J., June 19. For many years Mr. Bensel has been prominent in public life. He served the city of New York as chief engineer and later commissioner of the Department of Docks and Ferries and as president of the New York Board of Water Supply which was engaged in the construction of the Catskill aqueduct. In 1910 he was elected president of the American Society of Civil Engineers. At the end of his second term as state engineer in 1915 Mr. Bensel engaged in private practice in New York. During the war he served as a major in the engineer corps and was connected with the construction of cantonments in this country. Up to the time of its dissolution this year, he served on the board of consulting engineers on the Hudson River vehicular tunnel.

The Delaware River Bridge Joint Committee on June 2 awarded the contracts for the construction of both the Philadelphia and the Camden anchorage piers to the Keystone State Construction Co. and Holbrook, Cabot & Rollins Corporation. The winning bid on the Philadelphia anchorage was $928,535 and, on the Camden anchorage, $1,164,920.

The U. S. Bureau of Public Roads has received, as surplus war material, 780 ten-ton caterpillar tractors and 200 five-ton tractors. They are located at Camp Lewis, Wash., and the Erie Proving Grounds in Ohio. Distribution in the States will be completed and all should be in use in June.

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TABLE OF CONTENTS

Concrete Roads and Road Vehicles in England. By Frederick C. Horner 345
The North Circular Road 348
Ask for Paths Along Highways 350

EDITORIALS:

Valuable Investigation of Highway Transport . 349
The Canadian Good Roads Convention . . . 349
Incidental Benefit from Hard Times 349

MEETINGS:

Calendar 351
Canadian Good Roads Association Holds Successful Meeting 351
A. S. T. M. Elects Burgess President . . . 352

PERSONAL MENTION 352

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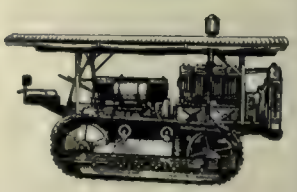

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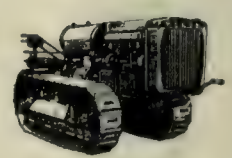

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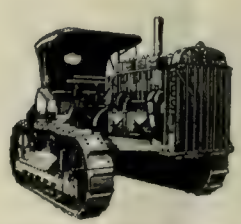

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WITH WHICH IS INCORPORATED

THE HIGHWAY CONTRACTOR AND ROAD BUILDER

Vol. LXII. NEW YORK, N. Y., JUNE 28, 1922 No. 26

Concrete Roads and Road Vehicles in England

By FREDERICK C. HORNER†

In an article published recently in an American technical magazine, the statement was made that in future the roads of England will all be of concrete, 18 in. in thickness and that, even now, nothing but 18-in. concrete roads are being built there. This statement is entirely misleading.

In order that those in America interested in good roads should not be misled by such an assertion—though I doubt whether any experienced engineer would be misled by it for a moment, when the cost of an 18-inch concrete road is considered—I will give the result of my personal investigation of this question, made on the spot during the last eight months, and in the course of which I have been able to obtain the opinions of some of the best road engineers in England.

First of all, I would state that, at the present time, there are no concrete public roads in England 18 in. thick, in fact none over 12 in. in thickness, and these are of clinker concrete and scarcely worthy of mention, as they are found only at a few places where the nature of the soil, marshy for instance, required a deep foundation.

There are not over 50 mi. of concrete road in the whole United Kingdom. One of the oldest pieces is to be found in Kent, and was laid about 1914. English road engineers are not by any means convinced that concrete roads are as good for English purposes as other types of construction. Therefore any report to the effect that the English roads are in future to be built of concrete is entirely without foundation.

As a matter of fact, it is extremely doubtful whether concrete roads will ever be proved to be best for English vehicular traffic. One of the main reasons is the large number of steel tired vehicles in use here. By steel tired vehicle, I refer especially to the steam wagon, of which there are over 16,000 in the United Kingdom, and to the horse-drawn vehicle. The latter is still a big factor in road transport in England and some of the horse drays are of large capacity. The horses are heavy draft and consequently their big steel-shod feet cause considerable damage to the roads Some of the steam wagons loaded are a gross weight of 12 to 13 tons and, although by law restricted to 5 mi. per hour, often run at 10 to 12 mi. per hour with consequent great damage to any road surface, but especially to a concrete surface.

In this connection, the question arises whether the very satisfactory results given by concrete roads in America would have been obtained if as many steel-tired vehicles were in use there as here in England.

In England, the best types of road are held to be asphalt and tar macadam. The foundation of the former is generally constructed of the old road bed material minus the worn-out top. On this foundation is laid about 2 in. of bituminous concrete on which is put about 1.25 in. of sheet asphalt. The tar macadam road is a slag tar macadam. Granite was tried, but found unsatisfactory. The perforations in the slag fill up with the tar and bind the whole mass together in such a way that, when the road must be taken up for some reason, it is found that it is so closely knit together that it can only be removed in big pieces. The granite type on the other hand separates very easily in comparison because the surface of the stone is so smooth that the tar does not bind the pieces together as it does the slag.

Regarding road surfaces, I have looked into the matter of wood block paving which is so popular here. The reason that wood blocks are so satisfactory as a road surface in England is due to the blocks being of soft wood. Hard wood blocks were tried on several occasions but were entirely unsatisfactory. The explanation is that the oak and other hard woods chip off on the edges, whereas the soft wood, pine largely, clings closer together and does not chip off. Most of the English wood blocks come now from Sweden and Norway. Another point about wood blocks for road surface in England is that it is not slippery as compared to the American wood block road surface. As pointed out to me, this no doubt is due to the practice

†Formerly transportation engineer of the Packard Motor Car Company and now an investigator of transportation conditions in England and the Continent.

of gritting the newly laid road with a gravel grit, from sand up to about the size of a pea, and letting the traffic grind it into the blocks. This grit gives the blocks a rough surface and, when they are dug up, it is found that they are still full of the grit. Another thing that is done in London and other English cities is to have bins of grit on the streets everywhere there are hills, and at points where traffic is very heavy. In wet weather, the road surface is gritted and, although one frequently sees horses slip on the streets in London, it is uncommon to see a horse fall down.

Moreover, I have never seen a motor vehicle with skid chains on in London. Of course there is very little snow and ice as a rule in London, but the streets are wet and muddy almost continually. In the north of England and in Scotland, they have considerable snow and ice and therefore do use skid-chains at times, but to nothing like the extent we do in America. An interesting fact in this connection is that in London all taxicabs are required to have one steel studded non-skid tire front and rear and on opposite sides. The results obtained are eminently satisfactory, as I have often had the opportunity to witness. Once I would have been run over but for a quick stop by a taxicab on a slippery street that would have been impossible without skid-chains or these non-skid tires. In America, we all know how often a driver to save tires and trouble will neglect to put on skid-chains when he should, thereby causing frequent accidents. Here the police regulations do away with this danger to the public, at least in so far as taxi-cabs are concerned. I am informed that eventually it is hoped to extend this regulation to all pneumatic tired vehicles.

The opinion of those road engineers with whom I discussed the subject is that main trunk roads in England should be a minimum width of 24 ft. and the county or feeder road not less than 18 ft. As to maximum width desirable, their views on this point can be judged by stating that, on one of the roads now being constructed in Middlesex County, Mr. Alfred Dryland, the engineer and surveyor, managed to have the width increased from 100 ft. to 120 ft. Although this road is not being built to the full width of the right of way at present and walks and trees on both sides will be included in the 120 ft. space, still it shows the vision of English road engineers in building their roads, where possible, not for the traffic of the moment alone, or for that of ten years hence, but for that of fifty years from now, or more.

Although this article is chiefly concerned with English roads, perhaps it would not be inappropriate to mention a few of the impressions of Mr. Alfred Dryland, to whom I have just referred, who went to America last summer to investigate our road building methods with special reference to the results obtained from concrete roads.

The principal defects seen by Mr. Dryland in American roads were their high crowns and their narrowness. Most of us will readily agree with him on both points, but especially on the latter. We all know the sensation caused by meeting a 7½ ton motor truck "crawling" along toward us at about 19 mi. per hour and possibly drawing a trailer that is weaving slightly.

In connection with the criticism of the high crowns of American roads, it may be stated that there are no crowns to English roads and the sides are not steep like ours, but rather flat.

Regarding the financing of our road building, one criticism Mr. Dryland makes—and it is a fair one in my opinion—is that borrowing money on 30-year bonds is "too long a shot"; fifteen years is a much safer proposition for all concerned. In this connection it has been pointed out to me that in America the property owner benefits so greatly from the good road that passes his home that he should pay an equitable portion of the tax necessary to raise money to build good roads. This is undoubtedly true and should not be forgotten. Moreover, as I was reminded, the motor vehicle owner in America will probably have to pay a greater tax than at present. The rate at present is much lower than the English one and our need for new roads alone, aside from the maintenance and repair of existing ones, is far greater than England's ever can be. The principal reason for this lies in our vast distances, the thousands of square miles awaiting the coming of the good road that will develop them.

It needs no stretch of the imagination to picture what a complete system of good roads will do for commerce generally and for the automotive industry in particular, to say nothing of what the benefits will be to every man, woman and child in the country. But as it will cost large sums of money to build these roads, taxation should be shared by all those able to pay, in the proportion that they benefit from the roads.

It is interesting to find that not only many of the motor vehicle operators, but some of the most experienced road engineers in England, are in favor of the petrol (gasoline) tax in place of the system of taxing according to horse-power and tonnage now in operation in England and America. They reason that the petrol tax is a fairer method, as it seems only right that the vehicle that travels 10,000 mi. per year over the roads should pay a higher tax than one that only travels 5,000 mi.

Regarding the weights and speed of motor vehicles, the road engineers with whom I have discussed the matter are of the opinion that 12 tons gross at 12 mi. per hour should be the limit for four wheel vehicles with rubber tires for any road. If the limits are raised much above these figures, the roads will not stand up and then the whole proposition becomes uneconomical from all standpoints. In other words, it would cost far more to build and maintain the roads, which would mean higher taxes for the vehicle and the property owner.

I might add that in opposition to this view a promi-

nent road engineer writes me on this subject as follows: "The motor car acts at the present time limit the weight, size and speed of vehicles but whether this is expedient or not, is a matter for the legislators, and it is for them to prescribe the maximum and for road engineers to construct their roads capable of withstanding the wear and stresses resulting therefrom."

My own observation on this point is that, unless legislators make wise laws, the taxpayer will suffer generally and the motor vehicle owner especially.

The report, that has been circulated in America to the effect that "over those 18 in. concrete roads in England they haul what they call steam lorries or traction engines, each engine pulling perhaps three cars holding 5 tons each," is true to this extent. The steam wagons weigh unladen from 5 to 7 tons and carry from 5 to 7 tons live load. The capacity is usually the lower figure and sometimes as low as 4 tons. One trailer behind is common practice. This type of vehicle is allowed to travel, when rubber tired, 10 to 12 mi. per hour. Then there is the "traction engine" which weighs 14 to 18 tons, is usually steel tired and hauls three 5-ton cap. trailers at a speed of 4 mi. per hour. Thus, the gross load of all four vehicles is approximately 50 tons. Three trailers is the maximum number allowed in one train. That this combination of road transport is growing in favor in England is not the case. In fact, I have never seen more than two trailers behind a traction in all the months I have been in England. The slow speed of this type of vehicle is sufficient reason to prevent it from becoming popular for anything except very heavy haulage, such as road building contractors, heavy haulage companies, etc. "More speed, faster vehicles" is the watchword of the road transport user, and greater carrying capacity where consistent with economy and existing legal requirements.

Right here, I would call attention to the fact that the over-loading evil is nothing like as prevalent in England as it is in America. Some owners do overload, but it is not by any means the rule. In fact, I am inclined to believe it is the exception, and without doubt excessive overloading is rarely practised here. This is largely due to the fact that when the English make a law they usually abide by it, whereas we in America seem to make a law and then premeditate how to break it before it goes into effect.

Referring to the growth of the 6-wheeler, or tractor and semi-trailer, I find that road engineers believe its use will be beneficial to the life of roads, as the more evenly the load is distributed the better the results should be, both for the life of vehicle and road. Especially will this be true if the largest size rubber tires are used on all wheels. The 6-wheeler of 10 tons capacity traveling at 12 mi. per hour would not do as much damage to the roads as the 6 ton capacity, 4-wheel vehicle, traveling at the same speed.

Every one I have talked with is most emphatic in commending the research work being carried on by the Bureau of Public Roads, Department of Agriculture, at Washington in the tests on road impact and sprung and unsprung weight. And they regret that there is no similar body to assist the road builders and truck manufacturers and operators in England, believing that it is only by these and other similar experiments and tests that we can arrive at definite conclusions as to what class of vehicle causes the greatest damage to the roads, and also get more light on what type of road construction stands the most wear. Of course, it is understood that no definite conclusions can be reached on this matter without taking into consideration the effects of weather, time and traffic.

The North Circular Road is one of the best and newest roads of concrete construction being laid in England.

Although this road is of reinforced concrete, the value of reinforcement for concrete roads is not generally conceded as yet by English engineers, for as one engineer put it to me, "so far, the high cost is not justified by the results obtained." But another opinion I received in a letter is in favor of reinforcement in concrete road construction, and is as follows:

"If it could be found possible to prevent openings being made in roads after construction, undoubtedly the reinforcement of the foundations, provided it is scientifically carried out, is advantageous and secures prolongation of life. The reinforcement of concrete does not, in my opinion, necessitate additional expense for the reason that the reduction in the depth of the concrete by reason of the reinforcement covers the extra cost of the latter. What I mean is, a road having an ordinary concrete foundation of 12 in. in depth would be no stronger than a road with 8 in. of concrete reinforced, and the cost of both contructions would approximately be equal."

At any rate, we have no reliable figures extending over a long enough period from which to form accurate conclusions on this question. Reinforced concrete roads are still in the experimental stage.

As stated in the first part of this article, about the oldest piece of concrete road in England is in Kent. It is a 6-in. slab with a 24-ft. roadway over which now passes about 1,200 tons per day. This road, although standing up very well, has not influenced the engineers of roads in Kent to build any other concrete roads. The fact of the matter is that the English road engineers are skeptical about the concrete road and it will take time to convince them that it is better than asphalt and tar macadam for English traffic.

It is interesting to note that there were no roads to speak of built in England for about 1,000 years after the Romans left and that the best roads until the advent of the motor vehicle, were built between about 1760 and 1830. The history of American roads is modern in comparison to England's, and we have ac-

complished wonders, considering the distances and the lack of cooperation due to there being separate states each with its own government, and consequently no central controlling body such as exists in England. We have only to continue the work of educating the people on the value of good roads in order to have a system of roads that will compare favorably with England and France.

To quote what Mr. Dryland wrote in "Concrete" after his return from America:

"Roads, as we understand them (in England), are a comparatively new thing in America; except in the cities, the need for them was not felt until the development of the motor industry. Railways were the basis of development and roads have only recently been deemed a necessary corollary. Distances between towns were great and they were all connected by railways. Access to a railway was the main consideration and, if there was a track sufficiently solid to allow the crops to be hauled to the stations, all necessary requirements were deemed to have been met. But the motor car has changed all that and now the fortunate owners (and an unprecedentedly large proportion of the population are owners) want to be able to travel in all directions, and to haul their produce direct to market without being restricted to the rail.

"In this country (England), long before the railways were thought of, we had been dependent upon roads for the handling of our commerce or for pleasure travel and there are few parts where something in the nature of a firm road did not penetrate. This goodly heritage we have been able to develop, strengthen, and utilize with more or less success to carry our modern traffic."

Therefore, let us give the people, who as Mr. Dryland says want to be able to travel in all directions, a complete system of roads. Then we too shall have a "goodly heritage" to leave to our children.

The North Circular Road

Details of Design and Construction of Concrete Road in Middlesex County, England, Typical of Latest Developments in Building Cement Concrete Highways in the United Kingdom

The North Circular Road, Willesden, which Mr. Horner mentions in his article in this issue as one of the best and newest concrete roads in England, is described in a paper prepared for a meeting of the Institution of Municipal and County Engineers in the Eastern District of Willesden on May 26, 1922, by F. Wilkinson, Engineer to the Willesden Urban District Council. The paper appears in full in the June 17 issue of "The Journal of the Institution of Municipal and County Engineers."

Work on this road was begun in 1920 under the provisions of the Unemployment Act and it has been a means of relieving a part of the distress in that district. From the beginning of the work down to the present time, it has been possible to give employment to 150 men weekly at the union rate. For the greater part of the time, the men worked for a period of two weeks and were supplied by the local labor exchange.

The road, which is about 3 mi. long, is divided into three sections. Section 1 is 4,380 ft. long and is nearly completed. The work on the second section of 3,800 ft. is in abeyance because, for the greater part of the distance, an 80 ft. road already exists and also because of the necessity for widening several bridges. Only the concreting remains to be done on the third section.

The width of the road, as designed, is 100 ft. That width will provide for a 16 ft. pathway on either side, two reinforced concrete driveways, and 20 ft. between the driveways as an accommodation for the necessities of future traffic, possibly for tramways. Only one driveway is being constructed at the present time.

Section 1

For the greater part of its length, Section 1 has for a foundation course 6 in. of well consolidated burnt ballast. The concrete is reinforced with the Walker-Weston reinforcement, 5 in. deep with 3-16 in. bottom bars and No. 6 S. W. G. diagonal members, the whole weighing about 12 lbs. to the super yd.

The mats, 5 in. in depth, were bent and assembled on the job 24 ft. wide and 6.5 ft. long to constitute one unit. When laid, each successive mat was properly joined to the previous one while in position on the road and just before the deposit of the wet concrete. Thus a uniform and continuous surface was obtained without joints.

The ballast was washed and screened, free from organic or loamy matter, sharp and angular, graded to pass through a 2 in. screen and to be retained on a 3-8 in. screen, square mesh.

The concrete, 8 in. in depth, was laid in two courses. The bottom 5 in. was composed of concrete of 5:2½:1 mix and the top course was 3:1:1 mix. The course aggregate, crushed rock, used in the bottom course was graded from 2 in. to ⅜ in., while in the top course it was graded from 3-8 in. to 3-16 in. The top course was placed upon the bottom course at once to form one mass.

The cement used on this work had to conform to the standard specifications of slow-setting cement. Great care was taken to determine the exact amount of water to add to the mixture under changing atmospheric con-

(Continued on page 350)

GOOD ROADS

CONSTRUCTION TRANSPORTATION MAINTENANCE

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Copy for advertisements must reach the New York office by noon on Tuesday of the week before date of issue if proofs are to be submitted.

Copy for classified and other advertisements where proofs are not required will be accepted until noon on Monday of the week of issue.

Articles by road builders are solicited. They should be short and, if possible, accompanied by photographs. Those accepted will be paid for at current rates.

Vol. LXII. June 28, 1922 Number 26

VALUABLE INVESTIGATION OF HIGHWAY TRANSPORT

The writer of the article on "Concrete Roads and Road Vehicles in England" in this issue has spent some months in England and on the Continent investigating highway transport. He expects to return to this country in October with a great deal of very valuable data on the subject. Formerly transportation engineer with the Packard Motor Car Company, Mr. Horner became deeply interested in the future development of transportation over the highways of this country. It seemed of the utmost importance to him to study the question of highway transportation in countries not so young as our own. England's roads are older and England is in advance of this country in the transportation of short haul and l. c. l. freight by motor truck. It was to study this system of transportation by motor truck as well as the construction of highways that Mr. Horner chose to spend most of his time in that country. He is particularly interested in the store-door-delivery by motor truck in England. His investigations, which he is carrying on independently, include: interviews with highway engineers, motor truck manufacturers and operators, etc.; traffic censi and other statistical information; and moving pictures and photographs. It seems certain that road builders and all persons engaged in highway transport in this country will benefit by the information that Mr. Horner will bring back with him this Fall.

THE CANADIAN GOOD ROADS CONVENTION

A great impetus towards road construction and improvement in Canada can not help but develop from the very successful convention of the Canadian Good Roads Association, an account of which is given elsewhere in this issue. In spite of the fact that the meeting was held far in the west, it was very well attended and brought together for the purpose of discussing road building problems many prominent engineers, public officials and business men. The program was well selected so as to bring about discussion of all of the live questions which confront the road builder to-day. For the bringing together of minds devoted to the subject and the interchange of ideas as well as the dissemination of special knowledge contained in some of the papers, the convention is to be commended.

It is further to be credited with creating a great amount of publicity for the cause of road building which will tend to interest a greater number of people in the vital question of investing the public funds in highways to the best advantage. The executives who managed the convention sent forth news releases galore and so handled the publicity that it is doubtful if many newspaper readers were not informed of the event more or less in detail. The mere fact that prominent and busy men will take the time and go to the expense of traveling nearly across a continent to attend a good roads convention is sure to arouse the interest of the laymen in good roads. It then becomes in his mind a matter of some importance. The papers read and addresses made by these men are given space in the local papers on their return and the reader is further interested and enlightened in the matter of highway construction and finance.

The Canadian Good Roads Association and its executives are to be congratulated on the success of their convention this year and urged to begin now to plan an even bigger and better one for 1923.

INCIDENTAL BENEFIT FROM HARD TIMES

There is little likelihood that the financial depression since the war will be looked upon by the general public as a blessing in disguise. It is a fact, however, that some benefits have arisen from the condition in the shape of public improvements. In numerous instances, much-needed improvements have been made under the stimulus of hard times with the main object of providing work for the unemployed.

In England, too, where the unemployment situation was more grave than in the United States, public funds were spent to give work to the men out of work. This policy has resulted in an extensive program of road improvement an example of which is the North Circular Road described in this issue. These roads which have been built to relieve unemployment, if properly constructed, will remain long after the condition which made them possible has been forgotten.

THE NORTH CIRCULAR ROAD

(Continued from page 348)

ditions. This question was considered of such great importance that records were kept and it was found that 11.5 gal. of water were used per cu. yd. of dry coarse concrete. For the top course using the finer aggregate, 19 gal. per cu. yd. were used. Broadly speaking, the concrete on this job was laid as dry as was practicably possible.

The concrete was mixed in a Lakewood mixer of ¾ yd. capacity with boom and bucket for distributing it over the road surface. The aggregate was brought to the mixture in wagons which contained a measured amount. The wagons were lifted bodily from the adjacent track and their contents tipped into the shoe of the mixer where the proper amount of cement was added. The water was added in the mixing drum.

The finishing of the surface was done by a Lakewood tamper and finisher which was supported on either side of the 24-ft. roadway by specially constructed steel forms 8 in. high. These forms were in 10-ft. lengths and were securely locked together after they had been set for line and grade. As a very highly finished surface was not desired, the canvas finisher was not used, the surface of the concrete being just as the tamper left it.

The levels of the roadway throughout its entire length have been and are being arranged at such a height as will allow, if required, for a 4-in. pavement of wood blocks.

It was not possible where the finishing machine was used to lay the curbs monolithic with the driveway. They were laid after the roadway was completed and the side forms removed. The depth of curb was 12 in.; the width 8 in. at the bottom and 6 in. at the top. Expanded metal reinforcement in 12-in. strips was laid in the vertical center line with expanded joints of tarred felt every 16 ft. The face toward the road was battered ½ in. and the back 1½ in. The bottom 7 in. mixed 6 parts 2-in. to ⅜-in. coarse aggregate, 1 part ⅜-in., 1 part sand, to 1 part cement. The top 5 in. mixed 3 parts ⅜-in. coarse aggregate, 1½ parts sand, to 1 part cement.

Section 3

Section 3, although to be of the same cross section, is of quite different type of construction as compared with Section 1. While the latter is very flat in its grades, the former runs along the side of a hill in very undulating country. The grades have been kept as flat as possible but still the cut and fill is much heavier than in Section 1.

Unlike Section 1, the foundation of Section 3 is formed for the greater part of its length of 6 in. of well-burnt clinkers. Also, owing to various reconstruction works in the vicinity, it has been possible to obtain at no cost 1,000 loads of old concrete which has been used in connection with these clinkers and forms a very reliable foundation for the concrete. The old concrete has been broken to pass a 4-in. ring, hand laid on a bed of clinkers, and the whole thoroughly consolidated to a total depth of 6 in. and well rolled to the proper curvature. The steel reinforcement to be used in this section is the B. R. C. fabric No. 9. The concrete will be similar in composition and method of laying to that in Section 1.

Drainage

The drainage of the concrete roadway on both sections is by means of gullies which are constructed off the line of the road, the curbing being returned around the gully grate. Section 1 traverses a housing tract where all provisions had been made for drainage but in the construction of Section 3 provisions had to be made for draining 265 acres of pasture land through which the road cuts. Such provision provides for about two-thirds of this acreage being fully developed by houses and roads. All natural ditches and watercourses have therefore been culverted in of sufficient cross-sectional areas and grades to cope with present and the future drainage. In all probability and in the near future, a main sewer will be constructed for the greater length of the road as far as the levels will permit which will give effective drainage to this district when it becomes developed. Provision has been made for electrical mains and other pipes under the concrete driveway where crossings are likely to be made so that the surface will not have to be disturbed.

Careful cost records have been kept and an interesting matter of record is the fact that, when the number of men employed was increased to further relieve the unemployment situation, the cost of excavation increased. After noting these costs for a few weeks, the force was reduced and the costs regained their normal economical point.

This road is being constructed by the Middlesex County Council in conjunction with the Ministry of Transport. The engineer for the council is Alfred Dryland, Esq.

ASKS FOR PATHS ALONG HIGHWAYS

A resolution urging the state highway commission to construct side paths along the state highways for the use of pedestrians was passed at the annual meeting of the New York State Motor Federation held recently at Syracuse. At the same time a resolution was passed which seeks to obtain legislation to prevent the parking of automobiles within 200 ft. of curves on state highways and an investigation was instigated to determine the feasibility of erecting comfort stations along the highways.

Sangamon County, Illinois, will supplement the state road building program by constructing this year 11 mi. of concrete highway at an approximate cost of $300,000.

Jefferson County, Alabama, is engaged in building 50 mi. of road at a total cost of $425,000. The money was raised by a bond issue.

MEETINGS

Calendar of Coming Meetings

June 26-July 1—American Society for Testing Materials—Twenty-fifth annual meeting, Atlantic City, N. J. Secretary, C. L. Warwick, Engineers' Club Bldg., Philadelphia, Pa.

August 4-5, Texas Highway Association—General convention at Galveston, Texas. Secretary-treasurer, Room 1910, F. & M. Bank Bldg., Fort Worth, Texas.

Aug. 9-10—Custer Battlefield Highway Association—Annual meeting, Sheridan, Wyo. Secretary, W. D. Fisher, Sheridan, Wyo.

Oct. 2-6—American Society for Municipal Improvements—Annual convention, Cleveland, O. Secretary, Charles Carroll Brown, St. Petersburg, Fla.

CANADIAN GOOD ROADS ASSOCIATION HOLDS SUCCESSFUL MEETING

Delegates from every province of the Dominion of Canada to the number of about 150 journeyed to Victoria, B. C., to attend the Ninth Annual Convention of the Canadian Good Roads Association which was held at the Empress hotel there, June 12 to 15. Included in the number were cabinet ministers, members of parliament, highway officials, engineers and prominent business men from all parts of Canada.

The opening session, Monday morning, was devoted chiefly to the registration of the delegates. Addresses of welcome were given by prominent officials of British Columbia and of Victoria and were replied to by S. L. Squire, a past-president of the association. At the close of the session, the delegates were the guests of the Victoria Automobile Club at a luncheon at which the president of the club introduced the question of an all Canadian coast to coast highway.

The afternoon session opened with a presidential address by Hon. S. J. Latta, Minister of Education for Saskatchewan, which covered a broad field and touched on all the legislative, financial, and engineering problems of the road builder. Mr. Latta spoke of the highways as a definite and most important part of the transportation system of a country and advocated the careful planning of a highway system that would fit in with railway lines so as to do the greatest good for the greatest number of people.

Prof. K. A. Clark, of the University of Alberta, gave the results of experiments which he has been conducting in the treatment of soils in a paper entitled, "Experiments in Improving and Maintaining Prairie Roads." The experiments had to do with reducing the property of the prairie soil to absorb water by the addition of bituminous material.

A paper on "Drainage of Prairie Roads" was read by H. R. MacKenzie, Chief Engineer for the Province of Saskatchewan. It dealt with surface and sub-drainage and the construction of side ditches and culverts. Mr. MacKenzie told why high crowned roads are not suitable for his province and described the trouble encountered on the prairie with drifting soil which annually fills up all the ditches.

Germain P. Graham of Albany, N. Y., District Engineer of the Asphalt Association, gave an illustrated talk on the use of asphalt for road building.

At the close of the afternoon session, the delegates were taken on a motor trip and shown the interesting points of the city and in the evening they were entertained at a theatre party.

The morning session Tuesday, of which A. J. Duschatel, Chief Engineer of Outremont, Que., was chairman, was opened by an address by A. W. Campbell, Commissioner of Highways for the Dominion Government, on "Federal Aid, Its Implications and Results." In the discussion that followed, the delegates from British Columbia made a plea for extra aid to cope with the greater natural obstacles which have to be met in that province.

A very interesting paper was read by J. D. Robertson, Deputy Minister of Public Works of Alberta, on "How to Improve Earth, Clay and Sand Roads." This paper gave the details of the methods employed in Alberta for grading roads through both prairie and wooded country and for constructing brush and corduroy roads.

The afternoon session began with an address by A. P. Sandles of Columbus, Ohio, in which the speaker set forth the importance of good roads as a force in building up a nation and made a plea for the construction of many miles of less expensive highways to be kept good by careful patrol and maintenance rather than the building of a few miles of costly pavement.

Hon. H. L. Perron, Minister of Highways of Quebec, outlined the highway program of that province inaugurated in 1912 which he said is now practically completed.

James Allen, Supervisor of Highways of the State of Washington, read a paper on "Portland Cement Concrete Roads" which appeared in the June 14 issue of "Good Roads."

The maintenance and repair of the road builder's plant was taken up in interesting fashion in a paper on "Road Machinery" by F. L. MacPherson of the Department of Public Works of Victoria.

At the close of the session, the following officers were elected for the ensuing year:

Honorary president, Hon. S. J. Latta, Regina; president, Hon. J. L. Perron, K. C., Montreal; first vice-president, R. T. Kelley, Hamilton; second vice-president, F. L. Fellowes, Vancouver; secretary-treasurer, G. A. MacNamee, Montreal; directors, Jos. Beaubien, Outremont; H. S. Carpenter, Regina; Wm. Findlay, Toronto; George Hogarth, Toronto; J. D. Robertson, Edmonton; P. Phillip, Victoria; S. R. Henderson, Winnipeg; G. F. Pearson, Halifax; R. D. Patterson, St. John; A. M. Rankin, M. P. P., Collin's Bay; T. J. Mahoney, Hamilton; H. H. Shaw, Charlottetown; P. J. A. Duschatel, Outremont; P. Gommery, Vancouver; R. H. Murray, Halifax.

The Wednesday morning session began with S. R. Henderson, President of the Manitoba Good Roads Association, in the chair. P. Phillips of the Department of Public Works of British Columbia described the system of the road building in vogue in that province.

Mrs. Mary Ellen Smith, M. P. P., pointed out the great natural obstacles to be dealt with in British Columbia and put in a word for the Canadian national coast to coast highway.

The subject of colonization roads was taken up in a paper by W. F. Fullerton, Superintendent of Colonization Roads for Ontario.

W. C. Cornell, Manager of The White Company, Seattle, Wash., presented a paper on "The Maximum Weights, Speeds, Widths, etc. of Motor Trucks." This paper set forth the truck manufacturer's view of the regulations which should govern the use of motor trucks on the highway.

T. J. Mahoney, Past President of the Ontario Good Roads Association, occupied the chair at the afternoon session. Hon. J. P. Hartman of Seattle was the first speaker. His subject was "Permanent Highways." In a comprehensive discussion of the value of all-year-round highways, Mr. Hartman also touched on the all important question of the relation between the railways and highway transportation. He gave it as his opinion that, although the rail lines would lose business to the motor trucks, they would reap a greater reward from the opening up of new country and the fostering of agricultural industry.

The next speaker was J. A. Duschatel who had the subject, "Foundation." He pointed out the importance of building base courses of permanent character so that the surface alone would need renewing.

The evening was given over to a banquet at which more than 300 guests were present and which was one of the most enjoyable features of the convention.

The Thursday morning session was opened promptly by the presiding officer, Hon. G. S. Henry. The first paper was read by John S. Crandall, Consulting Engineer of The Barrett Company of New York, on "Roads and Pavements for Average Conditions." The only other paper read at this session was on "Road Dragging and Maintenance Conditions," by Hon. H. S. Carpenter, Deputy Minister of Highways for Saskatchewan.

The papers presented at the afternoon session were not discussed in order that time should be left for a motor trip planned by the entertainment committee. These papers were devoted to the construction of bridges and culverts and to the methods of financing road construction.

All papers and discussions were of the utmost interest. The sessions were very well attended and the entertainment offered the delegates was excellent. All who attended left feeling that it was the best convention ever held by the association.

A. S. T. M. ELECTS BURGESS PRESIDENT

At the annual meeting of the American Society of Testing Materials held at Atlantic City, N. J., June 27, Dr. George K. Burgess, chief of the Division of Metallurgy of the U. S. Bureau of Standards, was elected president. Other officers elected were: Dr. Wm. K. Walker, vice-president; D. M. Buck, W. M. Corse, Dr. W. K. Hatt and J. R. Onderdonk, directors.

PERSONAL MENTION

Major L. D. Blauvelt, chief engineer of the Colorado State Highway Department, resigned June 8, after one year of successful management of the affairs of the department, to become chief construction engineer for the Moffat Tunnel Commission. The commission is to construct a 6 mi. tunnel under the Continental Divide and the work is to start at once. Major Blauvelt is a graduate of Rutgers College in New Jersey. He went to Colorado following his graduation in 1889 and became identified with the Colorado Midland railroad. Later he was engaged in the location and construction of the Cripple Creek Short Line railroad and mining operations at Cripple Creek. In 1902, he became locating engineer for the Denver & Salt Lake railroad and in 1910 became chief engineer for that road. Governor Shoup appointed him as head of the present highway department following the passage of the present highway law of Colorado at a time when a complete reorganization of the department was necessary. Assistant Engineer Reedy will be in charge of the highway department until a successor to Major Blauvelt is appointed. Governor Shoup has not indicated whom he will select for the position.

Leroy F. Wertz, assistant chief engineer of maintenance of the Indiana State Highway Department, has been appointed chief of the division of auditing to succeed John D. Williams who was recently made director of the state highway commission.

Dr. W. K. Hatt, Director of Highway Research, National Research Council, was elected a director of the American Society of Testing Materials at the business session of the annual meeting, June 27.

CONTRACT NEWS

CONTRACTS PENDING—REPORTED IN PREVIOUS ISSUES

Date of Letting		See GOOD ROADS issue of
ROADS AND STREETS		
7-10	Sacramento, Cal. Bit. mac. road	6-21
7- 5	Springfield, Ill. Various roads	6-21
7- 3	Angola, Ind. Gravel road	6-21
7-10	Belford, Ind. Gravel road	6-21
7- 5	Bloomfield, Ind. Mac. road	6-21
7- 5	Boonville, Ind. Broken stone and gravel road	6-14
7- 1	Brownstown, Ind. Drainage	6-21
7- 3	Cannelton, Ind. Gravel or stone road	6-21
7- 6	Columbia City, Ind. Gravel roads	6-21
7- 5	Crawfordsville, Ind. Gravel road	6-21
7- 5	Decatur, Ind. Stone roads	6-21
6-29	Fort Wayne, Ind. Streets	6-21
7-11	Fort Wayne, Ind. Concrete road	6-21
7- 3	Greencastle, Ind. Gravel road	6-14
6-30	Indianapolis, Ind. Concrete road	6-14
7- 5	Indianapolis, Ind. Bit. or cement concrete road	6-14
7- 3	Kentland, Ind. Gravel road	6-21
7- 5	Kokomo, Ind. Gravel road	6-21
7- 3	Knox, Ind. Various roads	6-21
7- 3	Lawrenceburg, Ind. Stone road	6-21
7- 5	Logansport, Ind. Gravel roads	6-14
7- 5	Madison, Ind. Various roads	6-14
7- 5	Marion, Ind. Two roads	6-14
7- 5	Monticello, Ind. Gravel road	6-21
7- 5	Paoli, Ind. Two roads	6-21
7- 5	Princeton, Ind. Nine roads	6-21
7- 3	Rensselaer, Ind. Two roads	6-14
7-15	Rensselaer, Ind. Road	6-21
7- 5	Rockville, Ind. Gravel road	6-21
7- 5	Shelbyville, Ind. Three gravel roads	6-21
7- 3	Shoals, Ind. Four roads	6-21
7- 3	Tipton, Ind. Gravel road	6-21
7- 3	Valparaiso, Ind. Four gravel roads	6-21
7- 3	Versailles, Ind. Two roads	6-21
7- 5	Wabash, Ind. Hard surface road	6-21
7- 5	Washington, Ind. Road	6-21
7- 3	Williamsport, Ind. Gravel road	6-21
7- 5	Boston, Mass. Two concrete, one bit. mac. road	6-21
7- 7	Bessemer, Mich. Bit. mac. road	6-21
6-30	Cadillac, Mich. Gravel road	6-21
6-30	Escanaba, Mich. Bit. mac. roads	6-21
7- 6	Grand Rapids, Mich. Concrete or bit. mac. road	6-21
7- 6	Iron Mountain, Mich. Gravel road	6-21
7- 6	Jackson, Mich. Grading	6-21
7-12	L'Anse, Mich. Grading & draining	6-21
6-30	Marshall, Mich. Concrete or bit. pavement	6-21
7- 5	Munising, Mich. Bit. mac. road	6-21
7-11	Sandusky, Mich. One gravel, one concrete road	6-21
6-30	Sunapee, N. H. Bit. mac. road	6-14
BRIDGES AND CULVERTS		
7- 1	Yorkville, Ill. Concrete bridge	6-21
7- 3	Versailles, Ind. Bridge repairs	6-14
6-30	Grand Rapids, Mich. Con. bridges	6-14
7- 6	Riverview, Md. Bridge	6-14
7-13	Chilicothe, Mo. Steel bridges	6-14
6-30	Concord, N. H. Concrete bridge	6-14
7- 1	Cleveland, Ohio. Concrete viaduct	6-14
7-11	Williamsport, Pa. Concrete bridge	6-14
7-11	Central Ferry, Wash. Substructure	6-14

ROADS AND STREETS

Bids Asked and Prospective Work

Los Angeles, Cal.—Bids will be received until July 3 by Bd. of Pub. Wks. City Hall for the construction of curbs, gutters, and sidewalks and grading on Maryland St. and portions of intersecting streets. Address City Engr.

Sacramento, Cal.—Bids will be received until July 3 by State Highway Comn. for the construction of 10.8 mi. of concrete paving in Santa Barbara Co.; 3.2 mi. of concrete and 5.6 mi. of asphaltic concrete surface with cement concrete shoulders in Orange Co. Address Austin B. Fletcher, State Highway Engr.

Sacramento, Cal.—Bids will be received until July 17 by State Highway Comn. for the construction of 11.3 mi. of road in Plumas and Lassen Cos. involving: 71,000 cu. yd. excav.; 225 cu. yd. class A concrete; 390 lin. ft. 12-in. corr. metal pipe; 150 lin. ft. 18-in. corr. metal pipe; 104 lin. ft. 24-in. corr. metal pipe; 92 each, hauling and setting monuments. Address Austin B. Fletcher, State Highway Engr.

Denver, Col.—Bids will be received until July 5 by U. S. Dept. of Agriculture at Custom House for the construction of 2.585 mi. national forest, of road in Crook Co., Wyo., involving: 14.5 acres clearing and grubbing; 6 036 cu. yd. rock excav.; 22.037 cu. yd. common excav.; 4 000 sta. yd. overhaul; 2.585 mi. finishing; 67 cu. yd. cement rubble masonry; 332 l'n ft. 15-in., 180 lin. ft. 18-in., 174 lin. ft. 24-in. corr. metal culverts; 745 lin. ft. rustic guard rail; one 20-ft. log bridge and 1,500 sq. ft. log cribbing. Address J. W. Johnson, Dist. Engr.

Denver, Col.—Bids will be received until July 7 by State Highway Dept. for grading 10.526 mi. of road between Norwood and Naturita, est. $62,918; for gravel surfacing 5.414 mi. between Hayden and Mt. Harris, est. $57,918. Address L. D. Blauvelt, State Highway Engr.

Atlanta, Ga.—Bids will be received until July 3 by J. N. Landis, City Hall, for paving various streets. Address H. L. Collier, City Engr.

Peoria, Ill.—Bids will be received until June 30 by Co. Clk. for furnishig approximately 500,000 gal. road oil. Address W. E. Emery, Co. Supt. of Highways.

Bloomington, Ind.—Bids will be received until July 5 by Bd. of Comrs. of Monroe Co. for grading, draining and paving with gravel, macadam, concrete, brick or stone a certain highway. Address Horace Blakely, Co. Aud.

Des Moines, Ia.—Bids will be received until July 3 by City Council for the construction of concrete curbing on York, W. 12th and E. 12th Sts., 3,791, 1,913, and 2,524 lin. ft. respectively. Address A. E. McGlothlem, City Clk.

Dubuque, Ia.—Bids will be received until June 30 by city for resurfacing 560 lin. ft. of street with bit. macadam and 154 ft. with Asbestophalt. Address City Mgr.

Hastings, Mich.—Bids will be received until July 7 by State Highway Comr. at Court House, for grading, draining, and surfacing to a width of 16 ft. with class B gravel 3.429 mi. of road in Hastings and Castleton Twps. and 3.136 mi. in Rutland Twp., Barry Co. Address Frank F. Rogers, State Highway Comr., Lansing.

Manistique, Mich.—Bids will be received until July 6 by State Highway Comr. at Court House for surfacing 4.131 mi. of road in Doyle and Mueller Twp., Schoolcraft Co. Address Frank F. Rogers, State Highway Comr., Lansing.

Port Huron, Mich.—Bids will be received until July 6 by State Highway Comr. at Court House for the construction of 0.947 mi. of concrete road in the village of Marysville, St. Clair Co. Address Frank F. Rogers, State Highway Comr., Lansing.

West Branch, Mich.—Bids will be received until July 12 by the State Highway Comr. at Court House for grading, draining, and surfacing with 16 ft. gravel and 18 ft. concrete 0.712 mi. of road in city of West Branch, Ogenaw Co. Address Frank F. Rogers, State Highway Comr., Lansing.

White Pigeon, Mich.—Bids will be received until June 29 by State Highway Comr. at the office of the Village Clk. for surfacing to width of 18 ft. with top course gravel 0.824 mi. of road in Burr Oak Twp., St. Joseph Co. Address Frank F. Rogers, State Highway Comr., Lansing.

Albany, Mo.—Bids will be recieved until July 5 by Gentry Co. for grading, constructing culverts, etc. on 2.803 mi. of road W. of Albany. Address Co. Clk.

Lebanon, Mo.—Bids will be received until June 30 by Lewis Co. for grading, construct- of 5.075 mi. of gravel road S. W. from Lebanon. Address Co. Clk.

Pineville, Mo.—Bids will be received until July 7 by McDonald Co. for grading and constructing necessary drainage structures on 4.972 mi. of road N. from Anderson. Address Co. Clk.

Warrensburg, Mo.—Bids will be received until July 5 by State Highway Comn. at Johnson Co. Court House for the construction of 1.653 mi. of 24-ft. graded earth road east and west from Montserrat involving: 15,921 cu. yd. earth excav.; 500 cu. yd. rock excav.; 116 cu. yd. concrete masonry; 8,749 lb. rein. steel; 147.5 lin. ft. 15-in. vit. clay pipe. Address A. C. Lingley, Div. Engr., Kansas City, or State Highway Comn., Jefferson City.

Helena, Mont.—Bids will be received until June 29 by State Highway Comn. for the construction of 3.87 mi. of road between Butte and Anaconda. Address John N. Edy, Ch. Engr.

Elizabeth, N. J.—Bids will be received until July 5 by Bd. of Freeholders of Union Co. for the construction of 5,567 ft. of Mountain Ave., asphaltic concrete on cement concrete base with cement concrete curbs and gutters; 10 374 ft. of Springfield Ave., rein. concrete. Address Jacob L. Bauer, Co. Engr.

Toms River, N. J.—Bids will be received until July 7 by Ocean Co. for the construction of 12 921 sq. yd. of rein concrete pavement on Main St., Barnegat; and 17,600 sq. yd. of cement concrete pavement in Borough of Tuckerton. Address J. M. Abbott, Co. Engr.

Albany, N. Y.—Bids will be received until June 30 by State Highway Comr. for the construction of 2.23 mi. of road from Tupper Lake toward Piercefield, Franklin Co., est. $72,485; 9.38 mi. between Old DeKalb and Heuvelton, St. Lawrence Co., est. $239,179; 5 mi. from Watkins toward Hector. Address State Highway Comr.

Albany, N. Y.—Bids will be received until July 3 by Bd. of Contract and Supply for the improvement of various streets. Address City Engr.

Rome, N. Y.—City plans improvement of streets to cost $106,885. Address J. L. Plunkett, City Engr.

Burlington, N. C.—Bids will be received until June 29 by city for the construction of approximately 13,000 sq. yd. concrete sidewalk. Address The Ludlow Engineers, Winston-Salem.

Dayton, Ohio—Bids will be received until July 1 by Van Buren Twp. for the construction of sidewalk, curb and gutter on both sides of Wilmington Pike from East Drive and Indian Riffle Rd. to Marshall Rd. Address Clark Powell, Twp. Clk.

Hamilton, Ohio—Bids will be received until July 7 by Bd. of Co. Comrs. for the construction of gravel road at Smith-Wampach farms. Address C. Z. Mikesell, Secy.-Clk.

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4 6-ton 24 in. ga. Cummings Locomotives.

2 7½-ton 24 in. ga. Baldwin Locomotives. 50 HP 4 cyl. engines, self starters, electric lights and signals. Two speeds either direction, gear transmission, multiple disc clutch. Send for photo. Guaranteed good as new.

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1 Foote Paver, Shop No. 1484, self propelling, steam driven, 2 bag batch. Overhauled, ready for work.

1 14E Rex Paver, caterpillar traction.

1 No. 11 Koehring Paver, wheel traction.

3 Lakewood sub-graders.

1 7-ton guy derrick, 55 ft. boom.

1 7-ton stiff derrick, 60 ft. boom.

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1 10-ton Buffalo-Pitts steam roller.

1 10-ton Austin gasoline road roller.

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1 Barber Greene wagon loader, reversible traction and self-feeding rotating discs, driven by 4 cyl. Buda gasoline motor. New 1920.

1 Type B Erie shovel, new 1917. Rebuilt.

1 35 HP Farquhar portable boiler and engine.

1 Derrick car, 8 wheel, M. C. B.

1 20-ton 8 wheel Ohio Crane. 50 ft. boom.

1 20-ton Browning Crane, 8 wheel, 50 ft. boom. Will rent.

1 Ledgerwood 7x10 DC DD hoisting engine and boiler.

1 Lambert 7x10 DC DD skeleton hoist.

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Springfield, Ohio—Bids will be received until June 30 by State Highway Dept. for the construction of 8,169 ft. of road; 16 ft. pavement, rein. concrete, est. $45,257, 12 ft. bit. macadam, est. $39,951. Address Leon C. Herrick, Director.

Providence, R. I.—Bids will be received until July 5 by State Bd. of Pub. Roads for reconstruction of 3.9 mi. of road in Town of Charleston. Address Chairman, State Bd. of Pub. Rds.

San Angelo, Tex.—Bids will be received until June 30 by Tom Green Co. for the construction of 13.43 mi. macadam and gravel base and 15.43 mi. asphalt surfacing. Address J. T. Mathison, Co. Judge.

Bids Received and Contracts Awarded

Bakersfield, Cal.—Kern Co. let contract for improving road near Taft involving 67,601 sq. ft. 8-in. and 19 103 sq. ft. 6-in. concrete pavement, 1,580 cu. yd. excav. and 300 cu. yd. borrow, to Worden, Wimmer & Jones, at $29,153.

Sacramento, Cal.—State Highway Comm. received bids June 12 as follows:

For grading 8.49 mi. and laying 5.1 mi. concrete pavement between Westerly Boundary and San Luis creek in Merced Co.; Kaiser Paving Co., Oakland, $160,503; Pacific Construction Co., San Francisco, $125,586; Bates & Rogers Constr. Co., Los Banos $158,576; Dillon, Patterson & Downs, Los Angeles $225 565; J. A. Costello Jr., San Francisco, $147,777; Bianco & Taylor, Vallejo, $135,384; C. H. & A. W. Gorrill, San Francisco, $160,866; John Doyle, San Jose, $196 834; Fredrickson & Shannon, Fresno, $149,116; Warren Constr. Co., Oakland, $135 532; Bates & Borland Oakland, $162,007. State to furnish materials, total $39,585.

For the construction of 12 26 mi. concrete road between San Luis Creek and Los Banos; John Doyle, $282,470; Bates & Rogers Constr. Co., $245 976; Dillon, Patterson & Downs, $269 984; Kaiser Paving Co., $320,749; Bates & Borland $239,084; Isbell Constr. Co., Fresno, $332,783; Bianco & Taylor, $216,550; Johnson Contr. Co., Portland, Ore., $246,781; Bonnell, Savage & Fenn, Tacoma, Wash., $260 491; General Const. Co., San Francisco, $303 013. State to furnish materials, total $93,162.

For grading 3.39 mi. and paving with concrete 17.36 mi. of road between Westerly Boundary and Los Banos; Southwest Paving Co., Los Angeles, $404,661; Kaiser Paving Co., $454,055; Blumenkranz & Vernon, Stockton, $413.719; Bianco & Taylor, $346,832; Bonnell, Savage & Fenn, $455 794; General Construction Co., $533.858; Bates & Rogers, $383,224. State to furnish materials, total $32,991.

For grading and surfacing with gravel 16.63 mi. of road between Trinidad and Freshwater Lagoon in Humboldt Co.; Pacific Constr. Co., $439,211; P. L. Burr, San Francisco, $465.350; Johnson Contracting Co. $598,362; Mercer Frazer Co., $503,106; Betchel & Engelhart, San Francisco, $474,179; Rajotte Winters Inc., Spokane, Wash., $470,932; A. J. Fairbanks, Willits, $470,962; Erickson Peterson Grier Co., San Francisco $500,024; Ralph McLeran & Co., San Francisco, $448 950; Palmer & McBryde, San Francisco, $498 552 State to furnish materials, total $78,626.

For grading 8.041 mi. between Johnstonville and Janesville; Dodge Bros., & F. W. Dudley, Fallon, Nev., $48,118; Warren Constr. Co., $37,056; J. Wilmshurst, San Francisco $45,669; Wemple & Riddels Susanville, $50,782; Jesse L. Franklin, Stockton, $52,311. State to furnish materials, total $5,552.

BRIDGES AND CULVERTS

Bids Asked and Prospective Work

Lawrenceburg, Ind.—Bids will be received until July 3 by Dearborn Co. for the construction of a concrete bridge over Leatherwood Creek in York Twp. Address Arthur E. Jackson, Co. Aud.

Nashville, Ind.—Bids will be received until July 3 by Brown Co. for the construction of 3 bridges, 102, 90, and 30 ft. span. Address B. S. Moser, Co. Aud.

Rockville, Ind.—Bids will be received until July 5 by Parke Co. for the construction of one culvert and two bridges. Address Ralph E. Porter, Co. Aud.

Versailles, Ind.—Bids will be received until July 3 by Ripley Co. for the repair of a bridge in Adams Twp. Address W. D. Robinson, Co. Aud.

Denison, Ia.—Bids will be received until June 30 by Crawford Co. for the construction of various bridges and culverts. Address Co. Aud.

Des Moines, Ia.—Bids will be received until July 3 by Polk Co. for raising south end of Valley Junction bridge. Address Co. Aud.

Eldora, Ia.—Bids will be received until July 6 by Hardin Co. for the construction of a 140-ft. span rein. concrete bridge over the Iowa River. Address Co. Aud.

Toledo, Ia.—Bids will be received until June 30 by Tama Co for the construction of 28 box culverts. Address Co. Aud.

Washington, Ia.—Bids will be received until July 6 by Washington Co. for the construction of one slab bridge and 41 culverts. Address Co. Aud.

OFFICIAL PROPOSALS

HIGHWAY WORK
Notice to Contractors

STATE OF MARYLAND
State Roads Commission

SEALED PROPOSALS for building five sections of State Highway, as follows:

Carroll County—Contract CL-39. One section of State Highway from Eldersburg to Freedom, a distance of 2.0 miles. (Concrete.)

Frederick County—Contract F-55. One section of State Highway through Emmitsburg, a distance of 0.53 miles (Concrete.)

Howard County—Contract HO-22. One sec-

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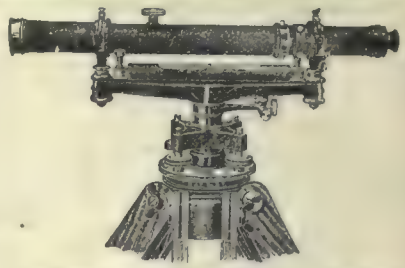

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tion of State Highway through Ellicott City, a distance of 0.4 miles (Concrete.)

Baltimore County—Concrete B-52. One section of State Highway from Jacksonville to sweet Air, a distance of 1.34 miles. (Contract.)

St. Marys and Charles Counties—Contract SM-17 and CH-24. One section of State Highway from New Market towards Dentsville, a distance of 4.0 miles. (Gravel.)

will be received by the State Roads Commission, at its offices, 601 Garrett Building, Baltimore, Maryland, until 12 M. Standard Time on the 5th day of July, 1922, at which time and place they will be publicly opened and read.

Bids must be made upon the blank proposal form which, with specifications and plans will be furnished by the Commission upon application and cash payment of $1.00, as hereafter no charges will be permitted.

No bids will be received unless accompanied by a certified check for the sum of Five Hundred ($500) Dollars, payable to the State Roads Commission.

The successful bidder will be required to give bond, and comply with the Acts of the General Assembly of Maryland, respecting contracts.

The Commission reserves the right to reject any and all bids.

BY ORDER of the State Roads Commission this 15th day of June, 1922.

J. N. MACKALL, Chairman.
L. H. STEUART, Secretary.

HIGHWAY WORK

Notice to Contractors

OFFICE OF STATE COMMISSION OF HIGHWAYS

SEALED PROPOSALS will be received by the undersigned at their office, No. 55 Lancaster Street, Albany, N. Y., at one o'clock p. m. on Tuesday, the 11th day of July, 1922, advanced standard time, which is twelve o'clock noon, Eastern Standard Time, for the improvement of highways in the following Counties:

CATTARAUGUS.....(one highway: 4 15)
CHENANGO.....(one highway: 8.82)
DELAWARE....(two highways: 7.59 & 7)
MADISON.....(one highway: 1.60)
ST. LAWRENCE.....(one highway: 10.14)
WASHINGTON.....(one highway: 0.62)
WYOMING.....(one highway: 4.68)
YATES.....(one highway: 2.92)

Also for reconstruction of the following:
CHENANGO.....(one contract: 1.27)

Maps, plans, specifications and estimates may be seen and proposal forms obtained at the office of the Commission in Albany, N. Y., and also at the office of the Division Engineers in whose division the roads are to be improved or reconstructed. The addresses of the Division Engineers and the Counties in which they are in charge will be furnished upon request.

The especial attention of bidders is called to "General Information for Bidders" in the itemized proposal, specifications and contract agreement.

HERBERT S. SISSON, Commissioner.
J. G. FINCH, Secretary.

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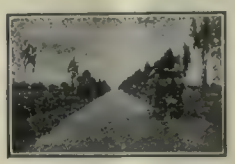

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No. 1818. Gov't new folding Canvas Cots — Covered with 30-ounce waterproof khaki Duck — on a hardwood frame. Price, per doz., $32.50

No. 154. Gov't Water Buckets— Collapsible, extra heavy, leak-proof canvas. 40 to a case. Price, doz., $3.60

No. 1702. Gov't Waterproof Duck —No. 6, thought to be 30-oz. wt., khaki color. Comes in 150 yard bolts. Price F.O.B. Louisville, Ky., or Chicago, per yard 27½c. Less than bolt lots, 35c

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No. 1810. Gov't Overalls and Jumpers — Brand new in original government bales of 50. No. 220 Denim Overalls bibless, loops for belts and buttons. Sizes up to 44. Jumpers buttoned or slip-over Dungaree style; sizes up to 50. Prices, per dozen, Overalls $6.50; Jumpers $6.00

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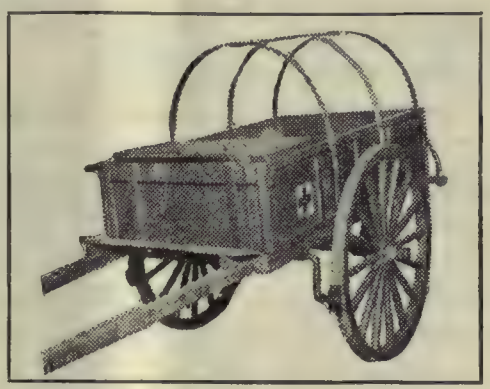
No. 811. Gov't Stencil Outfits— 1 set of 1-in. alphabets, 1 set of 1-in. figures, 1 set of 1½-in. alphabets, 1 set of 1½-in. figures, 1 can marking paste, 1 marking brush—all in wooden cabinet. Price complete, $1.00

No. 807. Gov't Stencils—30 pieces —brass, alphabets. Price per set, 35c

No. 805. Gov't Stencils—12 pieces —brass figures 1 in. long. Price per set, 20c

No. 1900. Gov't Hip Boots—First quality rubber. Sizes 7 to 11. One dozen pairs to case of a size. Price by the case, per pair, $2.25. 10 dozen lots, 2 dozen of each size, per pair, $2,00.

No. 84. Gov't Castile Soap—Genuine imported white. In 4-lb. bars, 18 bars, or 72 lbs. to the case. Price per bar, 60c. Per case, $9.00



No. 1701. Gov't Carts or Trailers— New. Strongest ingenuity could produce. Every conceivable reinforcement. The box is 8 ft. long, 4 ft. wide, 21 in. deep, about 1¼ in. thick. Wheels iron covered and about 3 in. thick; 60-in. diam. with 16 massive, solid spokes, 3 stakes for canvas cover. Shafts, chain tugs, seat, footboard, back chain and poles, etc. Best trailer money can buy. Gov't cost about $200.00. Immediate shipments, Price F. O. B. Hawthorne, Ill., [Chicago suburb], $25.00.

No. 158. Gov't Pyramidal Tents— Standard 12 and 16 ounce duck, Army tents. 16 ft. by 16 ft., 3 foot high side wall. 11 ft. high at center. White or khaki. Reclaimed but guaranteed perfect. Poles not included. Price, $14.

No. 1700. Gov't Tarpaulins—Genuine government 30-ounce waterproof duck. Heaviest mfd. Any size up to 150 x150 ft. Sizes below always in stock.

8 ft. x 10 ft. 6 in.	$ 5.60
10 ft. 6 in. x 12 ft.	8.40
10 ft. x 15 ft.	10.50
12 ft. x 14 ft.	12.25
14 ft. x 16 ft.	16.80
16 ft. x 20 ft.	22.40
20 ft. x 40 ft.	56.00

Any other size you desire at 7c per sq. ft.

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No. 156—Gov't Ponchos — Rubberized, waterproof. Reclaimed but perfect. 50 to bale. In bale lots, price each, 75c. Less than bale lots, 85c.

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No. 413. Gov't Mattress Covers— Brand new. Extra heavy twill muslin. In doz. lots, price each, 40c.

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No. 1711. Gov't Pup-Tent Poles —New. Best quality. Packed 720 to case.

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Price each in lots of 2,500	2½c
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No. 1812. Gov't Navy Wool Underwear. Medium weight, over 75% pure wool. Shirts sizes 36, 40, 42, 44. Drawers 34, 36, 38, 40. Shirts $6 per doz., drawers, $5.50.

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No. 567. Gov't Heavy Duck Pistol Belts, per dozen, 90c.

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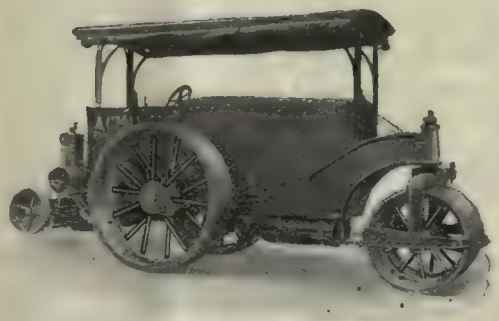

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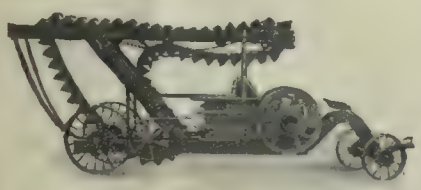

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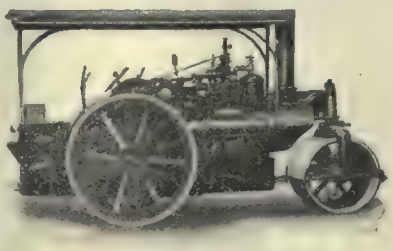

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Alphabetical Index To Advertisements

	Page
A	
Allis-Chalmers Mfg. Co.	—
Acme Road Machinery Co.	35
American Car Sprinkler Co.	34
American Steel & Wire Co.	3
American Tar Co.	34
Asphalt Assn., The	—
Austin Machinery Corp.	—
Austin-Western Road Machinery Co.	34
B	
Bacon, Inc., Earle Co.	—
Barrett Company, The,	4th Cover
Berger & Sons, C. L.	31
Best, C. L. Tractor Co.	4
Bonney Supply Co., Inc.	—
Breed, H. Eltinge	32
Buff & Buff Co.	31
Buffalo Springfield Roller Co.	34
C	
Construction Machinery Co.	—
D	
Diehl, George C.	32
Dow & Smith	32
Du Pont de Nemours & Co. Inc., E. I.	3d Cover
Dustoline or Roads	38
E	
Eugol Motor Truck Co.	—
F	
Flood & Co., Walter H.	32
G	
General Equipment Co.	30
Granite Paving Block Mfrs. Assn. of the U. S.	34
Green, L. P.	—
H	
Headley Good Roads Co.	38
Higgins & Co., Chas. M.	31
Howard, J. W.	32
I	
Ingersoll-Rand Co.	—
K	
Keuffel & Esser Co.	31
Kinney Mfg. Co.	3
Koehring Co.	2d Cover
L	
Luten, Daniel B.	32
M	
MacDonald, James H.	32
Meeker, R. A.	32
Metal Forms Corp.	—
N	
New England Road Machinery Co.	34
O	
Osgood Co.	—
P	
Packard Motor Car Co.	—
Pierce-Arrow Motor Car Co.	38
Pittsburg Testing Laboratory	32
Pollock, Clarence D.	32
Portland Cement Assn.	—
R	
Reading Engineering Co.	30
Robeson Process Co.	35
S	
Semet-Solvay Co.	—
Spencer, W. B.	30
Standard Oil Co., of Ind.,	3d Cover
Standard Oil Co., of N. Y.	37
U	
Universal Road Machinery Co.	34
W	
Warren Brothers Co.	32

(For Classified Directory See Page 36)

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DUMORITE

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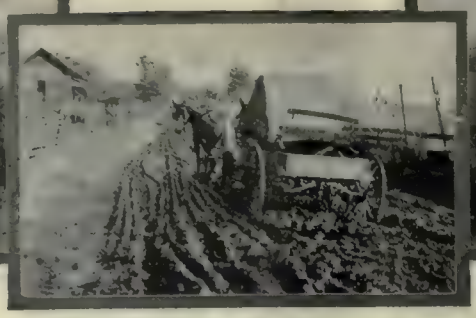
"Tarvia-X," 1920



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Carthage-Antwerp Road, N. Y.
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Glastonbury, Conn. "Tarvia-X," 1915

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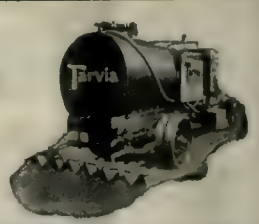

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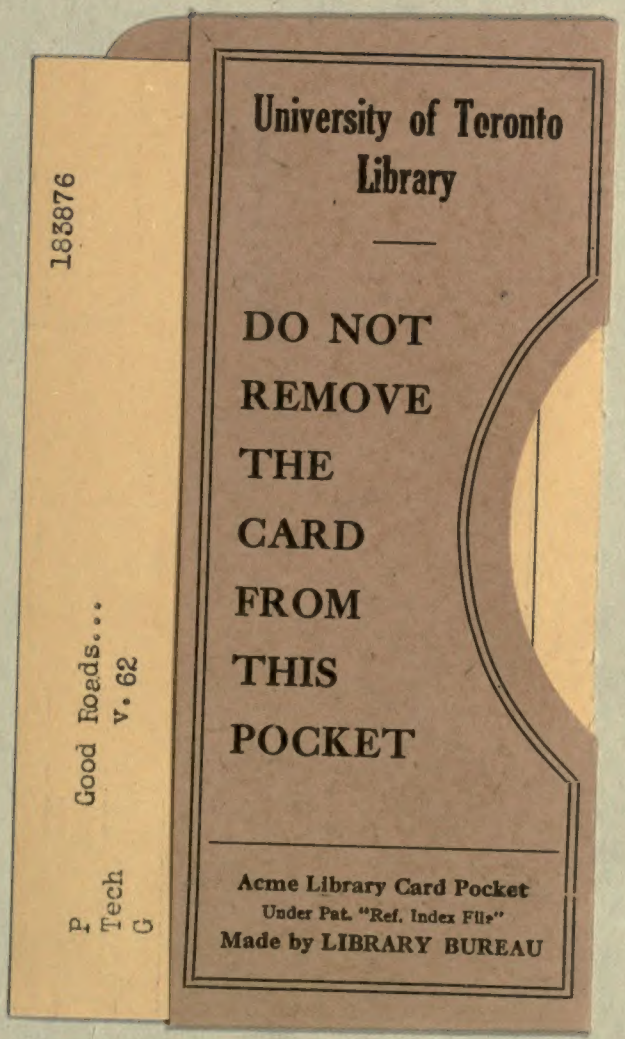
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